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# An Evaluation of Noncontingent Reinforcement Effects as a Function of Baseline Reinforcement Schedules.

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AN EVALUATION OF NONCONTINGENT REINFORCEMENT  
EFFECTS AS A FUNCTION OF  
BASELINE REINFORCEMENT SCHEDULES

A Dissertation

Submitted to the Graduate Faculty of the  
Louisiana State University and  
Agricultural and Mechanical College  
in partial fulfillment of the  
requirements for the degree of  
Doctor of Philosophy

in

The Department of Psychology

by  
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## ABSTRACT

An evaluation of fixed-time (FT) schedules and extinction was conducted with children who had mild to severe developmental disabilities. The principal research question was: Does the similarity between baseline (i.e., response-dependent) and FT reinforcement rates make behavior resistant to change? During Phase I, for each of 13 participants, a reinforcer assessment was conducted. Those individuals for whom a reinforcement effect was demonstrated continued to Phase II. During Phase II, the effects of FT schedules with either similar or dissimilar reinforcer rates (relative to a response-dependent baseline) and extinction were assessed for each participant. Results suggested that both extinction and FT schedules resulted in decreased responding. However, FT schedules were more effective in reducing response rates if the schedule was dissimilar (as opposed to similar) to baseline reinforcer rates. Collectively, these results might aid clinicians in the prescription of FT reinforcer delivery as treatment for problem behavior.



## INTRODUCTION

A response-independent schedule is defined as, "...a schedule in which the reinforcer appears independent of responses. In such schedules, the reinforcer is presented either periodically (fixed-time, FT, schedules) or aperiodically (variable-time, VT, schedules) without reference to responding" (Marr & Zeiler, 1974). In applied behavior analysis, response-independent schedules are often referred to as noncontingent reinforcement (NCR) and have been described as "...a response-independent or time-based delivery of stimuli with known reinforcing properties" (Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993). Because NCR disrupts a response-reinforcer relationship, it can be conceptualized as a form of extinction (Catania, 1969). That is, reinforcement depends on a contingency and when NCR is put in place following a reinforcement baseline, it disrupts a previously existing contingency. However, NCR is distinguished from traditional extinction in that the reinforcer is not withheld.

Fixed and variable-time schedules can be contrasted with fixed-interval (FI) and variable-interval (VI) schedules, which are response dependent schedules. During FI schedules, reinforcers are presented contingent on the first response following a set time period (e.g., 30 seconds). During VI schedules, reinforcers are presented contingent on the first response following an average time period (e.g., on average, every 30 seconds). In FT, VT, FI, and VI, the delivery of reinforcers is based, at least in part, on time. The difference between these schedules is that FT and VT schedules are response independent while FI and VI schedules are response dependent. An example of response-dependent reinforcement would be if a mother's attention was diverted (say, to a telephone conversation) and the only way a child can get her attention is to become disruptive. In this example, the delivery of attention depends on, or is contingent on disruption, and a child's disruptive behavior is more likely to occur in the future. By delivering attention on a NCR schedule, however, the parent accomplishes two therapeutic goals: (a) the contingency between problem behavior and attention (i.e., the reinforcer) is eliminated because attention is delivered response independently, and (b) the child's motivation to engage in problem behavior is reduced because attention is delivered freely.

Further analysis of NCR is needed for two general reasons. First, there are potential clinical benefits. Similar to extinction, NCR results in a decrease in behavior, which may be important for addressing problem behaviors such as aggression, self-injurious behavior (SIB), and property destruction. However, some negative side effects of extinction may be avoided with NCR because the reinforcer is still delivered (Vollmer et al., 1998). In addition, the use of NCR is often more easily implemented than other popular behavior-reduction procedures, such as differential reinforcement. For example, with differential reinforcement of other behavior (DRO), a care-provider would be required to monitor behavior throughout the interreinforcement interval. If a problem behavior occurred, the interval would need to be reset. If no problem behavior occurred, then the reinforcer could be delivered. Conversely, with NCR, a reinforcer is delivered at set points in time, independent of behavior.

A second general reason to study NCR is that response-independent schedules have been evaluated most extensively in laboratory research with nonhumans. Skinner (1948), for example, investigated the effects of response-independent schedules on the behavior of pigeons and found that such schedules lead to the development and maintenance of behaviors (such as wings flapping) exhibited contiguous with reinforcer delivery. Later experiments focused on response suppression and comparisons to traditional extinction (discontinuation of reinforcement) and found that traditional extinction resulted in quicker and more pronounced decreases in the behavior of nonhumans (Lattal, 1972; Rescorla & Skucy, 1969). Similarly, Lattal and Bryan (1976) evaluated the effect of concurrent NCR on fixed-interval (FI) performance in pigeons and found that a concurrent NCR FI schedule led to a reduction in response rates for the FI component. Collectively, the basic research findings show that NCR suppresses response rates, but traditional extinction does so more effectively.

Early applications of NCR focused on its utility as a control procedure. For example, Goetz, Holmberg, and LeBlanc (1975) used NCR and DRO as control conditions during an evaluation contingent reinforcement. During DRO, teacher attention was delivered following 30 seconds of noncompliance. During NCR, the child received attention independent of behavior. During contingent reinforcement, the child received

attention contingent on compliance. In the NCR and DRO conditions, compliance was lower than in the contingent reinforcement condition. The use of NCR as a control procedure demonstrated that stimulus presentation alone was not sufficient to increase compliance rates. Instead, compliance was dependent on contingent stimulus presentation. More recently, NCR has been used as a treatment for reducing problem behavior maintained by either positive or negative reinforcement (e.g., Vollmer et al. 1993). Vollmer et al. (1993) initially demonstrated NCR's utility as a treatment in reducing the attention-maintained SIB of three participants. Vollmer, Marcus, and Ringdahl (1995) extended those findings to the treatment of escape-maintained SIB by delivering breaks from tasks on a FT schedule to reduce two participants' escape-maintained SIB.

In typical applications of NCR as treatment, an assessment is conducted to identify reinforcers maintaining problem behavior (i.e., a functional analysis). At the outset of treatment, the identified reinforcer is delivered on a free and frequent basis and the schedule of reinforcer delivery is gradually thinned to make application more manageable (e.g., to FT 5 minutes or FT 10 minutes). Because the reinforcer is available on a free and frequent basis at the outset of treatment, many of the side effects of conventional extinction (such as response bursts) can be avoided (Vollmer et al., 1998).

Collectively, the results of applied studies show that NCR suppresses responding if the reinforcer is identified via a functional analysis. In fact, there is some evidence that NCR reduces response rates more effectively than extinction (Vollmer et al., 1998), which seems to contradict laboratory results. In their study with rats, for example, Rescorla and Skucy (1969) found both NCR and conventional extinction (i.e., complete withholding of the reinforcer) resulted in decreased response rates, but conventional extinction resulted in more immediate and larger decreases in behavior. Lattal (1972) also found that the introduction of FT and VT schedules (i.e., NCR) following FI and VI reinforcement schedules (i.e., baseline) resulted in decreased but stable response rates; extinction yielded less responding than both FT and VT schedules.

There are numerous procedural distinctions between laboratory and applied research using NCR, and some of these distinctions may produce different effects. For

example, it is possible the effectiveness of NCR is a function of the relation between baseline and NCR reinforcement schedules. If baseline schedules and NCR schedules are very similar, NCR may be less effective because the schedule is relatively less discriminable from baseline conditions. In most applied studies to date, the baseline and NCR reinforcer rates have been quite distinct. In most laboratory studies, baseline and NCR schedules are intentionally yoked, such as VI 2 minute, VT 2 minute (Rescorla & Skucy, 1969). If a NCR schedule is similar to a baseline schedule, it is possible that behavior may be (a) maintained by adventitious reinforcement (Skinner, 1948), or (b) maintained because the stimulus context is similar to baseline (Rescorla & Skucy, 1969). The purpose of this study was to evaluate NCR schedules that were either similar or dissimilar to baseline schedules, in terms of reinforcer rates.

## REVIEW OF THE LITERATURE

### Conventional Extinction

Extinction usually refers to the discontinuation of reinforcement or the reduction of responding that follows such an operation (Catania, 1992). Typically, extinction procedures include withholding a reinforcer that has been demonstrated to maintain a particular behavior. Along with a reduction in responding, there are several other characteristic effects associated with extinction. One such characteristic is the extinction burst. An extinction burst occurs when, concurrent with the onset of the extinction schedule, elevated rates, durations, or amplitudes of responding are exhibited before the behavior begins to decline (Alessandri, Sullivan, & Lewis, 1990; Lerman & Iwata, 1996). A second characteristic effect of extinction is response variation, sometimes including aggression. For example, Azrin, Hutchinson, and Hake (1966) showed that when periods of reinforcement and extinction were alternated, pigeons aggressed toward a partially restrained pigeon during extinction. A third characteristic of extinction is spontaneous recovery: If an organism is removed from the experimental setting following an extinction session, response rates at the beginning of the next session will usually be higher than response rates at the end of the previous session (Catania, 1992).

Extinction has been used for many years as a method to decrease inappropriate behavior exhibited by humans. Such application typically involves withholding a reinforcer following problem behavior. France and Hudson (1990), for example, implemented an extinction procedure to reduce nighttime sleep disturbances exhibited by 7 infants. In each case, during baseline, parental attention was provided following sleep disturbance. In the treatment (extinction) phase, parental attention was withheld following sleep disturbance. For each child, the intervention significantly reduced the amount of sleep disturbance although total suppression was not observed for all; for 1 of the participants, bursting was reported. The eventual decreases in sleep disturbance were maintained over follow-up periods ranging from 3 to 24 months.

The identification of the maintaining reinforcer may help contribute to the success of extinction as a treatment or treatment component in applied settings (Lerman & Iwata, 1996). Without first identifying the reinforcer maintaining the target behavior, a therapist

or experimenter may not withhold the correct reinforcer, thus hindering efforts to achieve the desired change in behavior (Vollmer & Iwata, 1992). Iwata, Pace, Kalsher, Cowdery, and Cataldo (1990) identified escape as the functional reinforcer for seven participants' self-injurious behavior (SIB) via a functional analysis. During baseline, escape was provided contingent on occurrences of SIB. During treatment, escape was no longer provided following occurrences of SIB. In addition to extinction, SIB resulted in immediate physical guidance through completion of the task (Extinction + Physical Guidance). For five of the participants, SIB decreased to zero or near zero levels during the extinction + physical guidance phase of treatment. For one of the remaining participants, decreased response rates were observed only after adding a response blocking procedure to the extinction + physical guidance. For another participant, treatment consisted of extinction + DRO. Thus, Iwata et al. (1990) demonstrated the utility of eliminating the relationship between the target behavior and its maintaining variable in a behavior-reduction procedure. However, it should be noted that the results may not have been due to extinction only. Because physical guidance also was presented following occurrences of SIB, the subsequent decrease in SIB may have been a result of punishment (i.e., aversive properties of physical guidance).

One of the drawbacks to using extinction is the possibility of negative side effects such as bursting. Lerman and Iwata (1995), in a review of 113 extinction studies, found that bursting was reported in 24% of cases following the onset of treatment. An extinction burst may be especially undesirable if the target behavior is potentially dangerous to the individual (e.g., SIB) or others in the environment (e.g., aggression). The use of NCR has been proposed as a means of interrupting the response-reinforcer relationship, resulting in reduced levels of aberrant behavior, while avoiding some of the negative side-effects of conventional extinction (Vollmer et al., 1993).

#### Noncontingent Reinforcement (NCR): Experimental analysis of behavior

Dozens of laboratory-based studies have evaluated NCR effects. Two principal findings are most relevant to the current study: (a) NCR reduces response rates in comparison to baseline (e.g., Zeiler, 1968; Lattal, 1972), and (b) NCR does not reduce baseline response rates to the same degree as extinction (e.g., Rescorla & Skucy, 1969).

### **Finding 1: NCR reduces response rates**

Zeiler (1968) investigated the effects of fixed and variable schedules of response-independent reinforcement (i.e., FT and VT) on pigeons' key pecking. During baseline, either the first response after 5 minute was reinforced (FI 5 minutes) or the first response after an average of 5 minutes was reinforced (VI 5 minutes). During the experimental conditions, response-independent schedules were implemented that corresponded to the interval schedules in effect during baseline. That is, reinforcers were delivered without reference to a behavior either at fixed or variable 5-minute intervals (FT 5 minutes; VT 5 minutes). Results showed decreased response rates during FT and VT schedules compared to FI and VI baselines. However, complete response suppression was rarely observed. In addition, differences were observed between FT and VT performance. Specifically, transitions from VI to FT or FI to VT resulted in increases and decreases respectively in the degree of positive acceleration of response rates between successive reinforcements. Variable-time schedules resulted in greater decreases in behavior, relative to FT schedules, regardless of whether they followed FI or VI schedules.

The findings of the Zeiler (1968) study were replicated by Lattal (1972). The effects of FT 1 minute and VT 1 minute schedules on the bar-pressing of rats were evaluated following baselines of FI 1 minute and VI 1 minute. Results were similar to the Zeiler (1968) study in that FT 1-minute and VT 1-minute schedules reduced, but did not completely suppress responding. Taken as a whole, the results of these two investigations suggested that NCR schedules, following interval-based reinforcement baselines, may result in decreased, but seldom totally suppressed, responding. However, it is important to note that the NCR schedules were intentionally made similar to the baseline reinforcement schedules.

The robustness of response-independent schedule effects was demonstrated by Lattal and Bryan (1976). In the previously reviewed studies, NCR and FI schedules were presented in a multiple schedule format. That is, each schedule (FI and FT or VT), correlated with a unique stimulus, was implemented by itself. Lattal and Bryan (1976), however, evaluated the effect of response-independent reinforcement on ongoing FI schedule performance. Two pigeons' key-pecking was maintained on a FI 5-minute

schedule. In the first experiment, the schedule was converted to FI 5-minute VT (concurrent FI 5-minute VT) schedule by adding a VT schedule to the existing FI 5-minute schedule. The VT values ranged from 0.5 minutes to 2.5 minutes. Various concurrent schedules were then implemented in the following order: FI 5, FI 5 VT 2.5, FI 5 VT 1.5, FI 5 VT 0.5, and FI 5 VT 1.5 (all values in minutes). Increases in VT reinforcer rates led to corresponding reductions in overall response rates for all subjects. That is, less responding occurred during concurrent FI 5 VT 0.5 than in concurrent FI 5 VT 2.5. Results were similar to Zeiler (1968) and Lattal (1972) in that response-independent schedules produced decreased but not totally suppressed response rates. Thus, the behavior-reductive effects of NCR schedules were demonstrated to be similar across complex schedules (i.e., multiple schedule in Zeiler, 1968 and Lattal, 1972; concurrent schedule in Lattal and Bryan, 1976).

Hutton and Lewis (1979) systematically replicated prior work by evaluating response-independent negative reinforcement to decrease behavior maintained by negative reinforcement in pigeons. During baseline, shocks were delivered at 3-s intervals unless a peck occurred on a specific key. Key-pecks were reinforced on a random-interval 45-second (RI-45 second) schedule with a 2-minute shock-free period. During the experimental conditions, shock-free periods were sometimes provided as a result of responding on the RI 45-second schedule and sometimes as a result of a response-independent random-time (RT) schedule. The response independent schedules were RT 8 seconds, RT 19 seconds, RT 37 seconds, and RT 81 seconds. For each subject, the RT schedules resulted in lower response rates. In fact, the lowest response rates corresponded with the highest NCR rate (i.e., RT 8 seconds). However, similar to the studies on response-independent positive reinforcement, complete suppression of behavior was not obtained.

**Finding 2: NCR does not reduce response rates to the same degree as extinction**

Also in the laboratory, NCR schedules have been compared to other behavior reduction processes. In a comprehensive study of NCR and extinction effects, Rescorla and Skucy (1969) reported four experiments comparing VT to conventional extinction



(EXT) on the bar pressing behavior of rats. The first three of these four experiments will be reviewed here. In the first experiment, subjects were placed in one of four groups. Following shaping and FI 1-minute reinforcement for each of the four groups, subjects in one group (VI) were exposed to a VI 2-minute schedule, a second group (EXT) was exposed to extinction (that is, no reinforcers were delivered), a third group (VT) received reinforcement on a VT 2-minute schedule, the final group also received reinforcement on a VT 2-minute schedule, but never received reinforcement within 5 seconds of a bar press (delay group). Results showed extinction produced an almost complete suppression of behavior for the EXT subjects. Both the VT and delay groups demonstrated response decreases; however, complete response suppression was never achieved for either group. Extinction, then, resulted in the most pronounced and sustained behavior reduction.

Lattal (1972) replicated the findings of the first experiment described by Rescorla and Skucy (1969). Extinction was presented along with FI or VI schedules of reinforcement on a multiple (i.e., alternating) schedule. During the extinction component, responding decreased and approached a zero rate after about 10 sessions. In another phase, VT schedules were alternated with FI and VI schedules. Unlike extinction, VT schedules produced relatively high response rates (10 responses per minute after as many as 50 sessions). Thus, the extinction schedule appeared to be more effective in reducing behavior.

One possibility for the higher response rates in NCR (compared to extinction) as implemented by Rescorla and Skucy (1969) and Lattal (1972) was that some of the reinforcers were delivered contiguous with the target behavior resulting in adventitious reinforcement. Skinner (1948) demonstrated that when reinforcers were presented on a time-based schedule independent of responding, behavior might be maintained. Skinner presented food to pigeons independent of the bird's behavior at regular intervals (once every 15 seconds). For six of the eight birds, unusual behavior began to increase in frequency apparently due to their contiguous relation to the reinforcer delivery. The behaviors observed included turning, head thrusts, head "tossing," a pendulum motion, and pecking or brushing movements directed toward the floor. Skinner's work demonstrated that response-independent delivery of reinforcement can shape and maintain

behaviors that do not have any specified relationship to reinforcers. As such, it is possible key pecking and lever pressing are similarly maintained in laboratory NCR studies.

The second Rescorla and Skucy (1969) experiment was designed to investigate the potential role of adventitiously maintained bar pressing (i.e., bar presses that were incidentally reinforced) in the VT condition. Rats were trained to bar press on a VI 2-minute reinforcement schedule. They were then divided into five groups. These groups each received NCR at varying points during an EXT phase: Group 1 received free food on the first day of extinction and everyday thereafter; Group 2 received free food from the second day on; Group 3 received free food from the fourth day of extinction; Group 4 received free food from the eighth day of extinction; Group 5 received the normal no-food extinction (NF). Results demonstrated that delivery of free food throughout extinction (Group 1) greatly slowed extinction when compared to the NF group. Also, each group receiving free food displayed response decrements over sessions to approximately the same response asymptote. The authors concluded superstitious responding did not contribute significantly to the continued responding during NCR because higher response rates during the various free food conditions were not correlated with different response asymptotes. That is, greater response rates did not lead to correspondingly slower extinction during free food conditions. However, it does not necessarily follow that higher response rates would result in a greater likelihood of superstitious (and thus, sustained) responding. Although there may be a better chance for responding to occur contiguously to reinforcer delivery when response rates are higher, a reinforcement effect requires only that the probability of a reinforcer delivery following a response is greater than the probability of response-independent reinforcer delivery (Hammond, 1980). Raw response rates alone do not provide enough information to ascertain or identify an incidental reinforcement effect. Thus, it remains possible that the sustained responding displayed in each of the free food conditions was due to adventitious reinforcement. The authors go on to state that, rather than appealing to superstitious behavior (i.e., incidental reinforcement) as an explanation for the differences observed during extinction and free food conditions, food delivery per se may

have certain stimulus characteristics that evoke a variety of behaviors including bar pressing.

The third Rescorla and Skucy (1969) experiment was designed to investigate the role of food as a stimulus evoking learned bar-pressing responses. Rats were divided into four groups. On the first day of training, two groups were trained to bar press on continuous reinforcement (Groups C-E and C-NC, where C=continuous reinforcement, E=extinction, and NC=noncontingent reinforcement). The other two groups, (NC-NC and NC-E) received 20 food pellets on a VI 1-minute schedule to ensure training. Following training, bar pressing was maintained on a VI 2-minute schedule for the contingent groups (C-E and C-NC), but food was presented response independently on a VT 2-minute schedule for the noncontingent groups (NC-E and NC-NC). After five days of sessions at these schedules, extinction was implemented. For groups C-NC and NC-NC, NCR was in effect on a VT 2-minute schedule; bar pressing had no effect on reinforcer delivery. For the other two groups, no food was delivered. Results indicated that free food delivery elevated bar-press rate regardless of prior history of conditioning. However, the effect of free food was magnified by a prior history of bar-press training. These results suggested that much the behavior normally observed under these schedules may not have been maintained by the reinforcement contingencies. That is, higher levels of behavior may be observed in NCR relative to EXT due to the free food stimulus characteristics. This interpretation is consistent with the findings of Uhl and Garcia (1969), who showed that rats pressed a lever after receiving food on a DRO schedule. The food seemed to serve a discriminative function.

Collectively, the Rescorla and Skucy (1969) experiments suggested (a) NCR leads to behavior decrements at a slower pace than EXT. These results were further supported by Lattal (1972); (b) adventitious reinforcement did not play a large role in the sustained responding (although this finding is not conclusive); and (c) sustained responding during NCR was due at least in part to the stimulus characteristics of food.

The findings of the laboratory studies reviewed seem to have two important implications for applied research: (a) behavior can be reduced by presenting reinforcers on a time-based schedule; and (b) behavior can be reduced with more efficiency by

withholding reinforcers altogether. For example, if a problem behavior was maintained on a VI 5-minute schedule in baseline, it would be possible to reduce the amount of behavior exhibited by delivering reinforcement on a FT 5-minute schedule. However, complete suppression of the behavior may not be observed and some level of behavior may persist for quite some time (Lattal, 1972). If, on the other hand, all reinforcement for the behavior was withheld (e.g., extinction was implemented), complete suppression of the behavior would be observed, often in less time than required for NCR to achieve the same effects. However, it is possible this finding is produced by a procedural nuance: NCR schedules are almost always yoked to baseline reinforcement schedules. Applied studies have done the opposite: NCR schedules are almost always very different than baseline schedules. If similar baseline and NCR schedules are ineffective in reducing behavior, practitioners should be sure to prescribe distinct schedules. To date, however, the relation between baseline and NCR schedules is unknown. In addition, it is unlikely that practitioners would ever implement a strict extinction schedule in which reinforcers were never delivered. As such, more research is needed to evaluate how response-independent reinforcers should be delivered, when the goal is to decrease behavior.

#### **Noncontingent Reinforcement: Applied behavior analysis**

Several applied studies have also evaluated NCR effects. Two principal findings are most relevant to the present research: (a) NCR reduces behavior rates, and (b) NCR appears to reduce behavior rates more effectively than extinction. The first finding is consistent with laboratory findings. The second finding is inconsistent with laboratory findings, so possible reasons for the discrepancy should be explored.

#### **Finding 1: NCR reduces response rates**

When stimuli are presented contingent on behavior, two variables are introduced: (a) the mere presence of reinforcing stimuli, and b) the contingent presence of reinforcing stimuli. As a control procedure, NCR allows the effects of the mere presence of reinforcing stimuli to be compared to the contingent delivery of those reinforcing stimuli. Baer and Sherman (1964) provided an early example of the behavior-reductive effects of NCR. Three imitative behaviors (head nodding, mouthing, and strange verbalizations) in

11 children were reinforced on a fixed-ratio (FR) 1 schedule (that is, after each response) with adult attention during baseline. In this baseline condition, the rate of a fourth, nonreinforced behavior, imitative lever pressing, was found to increase. Next, reinforcers were delivered response independently (i.e., NCR). Response-independent reinforcer delivery resulted in decreases in the bar-pressing rates regardless of the model presence. This result demonstrated reinforcer presentation per se was not sufficient to increase imitation rates. Instead, increased rates depended on a contingent relationship between the target behavior and the reinforcer. These results also provided an early indication NCR could be used to decrease behavior in humans.

In another example, Goetz et al. (1975) compared NCR to DRO as control procedures during the modification of a preschooler's compliance. Teacher presence previously had been identified as a reinforcer for the child's compliance. Contingent reinforcement, NCR and DRO conditions were presented using an ABACABACA reversal design (A=contingent reinforcement, B=NCR, and C=DRO). During the contingent reinforcement phase, teacher presence was contingent on compliance. During NCR, the child received attention independent of behavior (i.e., following occurrences of compliance or noncompliance). During DRO, the child received attention following 30 seconds of noncompliance. During both the NCR and DRO phases, compliance was lower than the contingent reinforcement phase. Although NCR reduced an appropriate behavior (compliance), this finding led subsequent researchers to hypothesize NCR may reduce problem behavior with equal effectiveness (Vollmer et al., 1993).

More recently, NCR has been compared to differential reinforcement and extinction as a treatment for severe behavior problems. The use of NCR as a behavior-reduction procedure is based on several characteristics of response-independent reinforcer delivery. First, this type of delivery disrupts the contingent relationship between the response and reinforcer. Second, providing the reinforcer on a free and frequent basis may reduce the individual's motivation to engage in the target behavior because the reinforcer is already available. Third, the use of response-independent schedules may reduce the likelihood of side effects often observed during extinction-based procedures.

Vollmer et al. (1993) compared NCR to DRO as treatment for 3 women exhibiting attention-maintained SIB. Following a functional analysis that identified attention as the reinforcer for SIB, a baseline was conducted during which SIB was reinforced with attention on a continuous (FR 1) schedule. During the FR 1 baseline, each occurrence of SIB resulted in 10 seconds of attention from a therapist. During DRO, attention was delivered according to a resetting DRO schedule. The DRO interval was determined by computing the mean interresponse time for the preceding 3 sessions for one participant and the preceding 5 sessions for the other two participants. If the participant did not engage in SIB for the entire interval, 10 seconds of attention was delivered; occurrences of SIB reset the interval. During NCR, 10 seconds of attention was delivered on a FT schedule. At the outset of NCR, attention was delivered on a continuous basis. NCR was subsequently faded across sessions until attention was delivered on a FT-5 minute schedule. The results demonstrated that NCR was as effective as DRO for decreasing attention-maintained SIB. In addition, no bursting was observed following NCR implementation and there were no reported response variations typical of extinction procedures. Further, the authors suggested that NCR may be more practical than DRO because behavior did not need to be constantly monitored during the prespecified interval (i.e., there was no need to reset a timer).

The effect of noncontingent escape (NCE; that is, escape from instructions presented response independently) on problem behavior maintained by negative reinforcement have also been investigated. Vollmer et al. (1995) used NCE to reduce escape-maintained SIB for two children. During baseline, each occurrence of SIB resulted in a break from task (lasting approximately 20 seconds). During NCE, breaks were delivered on a FT schedule. Similar to the Vollmer et al. (1993) study, escape was provided continuously at first and the FT interval was gradually increased across sessions. Results suggested that NCE was effective for reducing behavior maintained by negative reinforcement.

For many practitioners, a rich schedule of reinforcement at the outset of treatment may not be feasible. This potential drawback has led to parametric research of NCR procedures. Hagopian et al. (1994) used NCR to reduce destructive behavior displayed

by quadruplets with developmental disabilities. For each of the four children, attention was identified via a functional analysis as the reinforcer for destructive behavior. During baseline, the children received brief attention following each occurrence of destructive behavior. During NCR, two different schedules (dense and lean) were implemented using a multielement format. During the dense schedule, attention was provided on a continuous basis. During the lean schedule, attention was provided on a FT 5-minute schedule. While both schedules resulted in decreases in destructive behavior, the dense NCR schedule resulted in a more marked decrease. However, it should be noted that neither the dense nor the lean schedules were based on the children's baseline behavior rates. Instead, these schedules represented the beginning and ending points of the fading achieved in the Vollmer et al. (1993) study. Basing the NCR schedule on baseline reinforcer rate (rather than FT 5 minutes) may be a less arbitrary indication of "dense" or "lean."

In an effort to incorporate baseline data into the calculation of NCR intervals, Lalli, Casey, and Kates (1997) conducted a study in which the initial NCR interval was based on the mean latency to aberrant behavior during baseline (i.e., the amount of time between the manipulation of the establishing operation and the first instance of a behavior problem). For each of two participants, decreases in problem behavior were observed following the implementation of the latency-based FT schedule. The results of the study suggested that it is possible to start treatment with leaner schedules than had been previously demonstrated (e.g., Vollmer, et al., 1993; Hagopian, et al., 1994). However, it should be noted that the characteristic response pattern seen in the Vollmer et al. studies (i.e., nearly complete response suppression at the outset of treatment) was not obtained by Lalli et al. Thus, while basing the initial NCR interval on a mean latency may result in decreased responding over time, response rates at the outset of treatment may be lower when continuous NCR is available. This effect should be taken into consideration when applying NCR to a potentially dangerous behavior.

While the results of the Vollmer et al., Hagopian et al., and Lalli et al. studies provide a strong basis for applying NCR in clinical settings, they do not address the mechanisms of NCR effects. At least two possible mechanisms have been posited for the

behavior-reductive properties of NCR: (a) extinction and (b) satiation. Rescorla and Skucy (1969) stated that complete withdrawal of the reinforcer is but one example of "...a large class of procedures which eliminate the response-reinforcer relation" (p. 381). NCR was considered by Rescorla and Skucy to be another example of extinction because, even though reinforcers are presented, the response-reinforcer relationship is disrupted. Vollmer et al. (1993) contended that it was unclear whether NCR had its effect due to satiation or extinction. However, Vollmer et al. (1995), along with Rescorla and Skucy, conceptualized NCR as a form of extinction due to the interruption in the response-reinforcer relationship. Lalli et al. (1997) hypothesized that NCR was effective mainly due to the effects of satiation. That is, because the reinforcer is available on a free and frequent basis, the individual may no longer engage in the behavior that produced the reinforcer in the past because there is no motivation to obtain the reinforcer.

Marcus and Vollmer (1996) provided preliminary empirical evidence for NCR as a form of extinction. First, a functional analysis showed that problem behaviors were maintained by access to materials. Next, differential reinforcement of alternative behavior (DRA) was superimposed on a NCR schedule in the treatment of aggression, SIB, or tantrums for three individuals. In DRA, participants were given access to the materials contingent on appropriate mands. However, they were also given access to the materials noncontingently on a FT schedule. If NCR produced satiation, appropriate requests for materials should not have occurred when both schedules (DRA and FT) were in place. However, in all three cases, problem behaviors decreased, while appropriate requesting was maintained. This finding indicated that the behavior-reductive effects of NCR may be more similar to extinction than satiation: The maintenance of appropriate requests indicated that participants were still motivated to receive the reinforcer even when it was provided response-independently (DRA + NCR). Similar results have been reported in the laboratory. Lattal and Bryan (1976), for example made reinforcers available on both response-independent and FI schedules; key pecking, although reduced, was not eliminated.

The analyses of satiation effects in NCR are not definitive. Some findings suggest the role of satiation may be idiosyncratic. Lalli et al. (1997), for example,



implemented NCR with extinction with two participants and NCR without a conventional extinction component with one participant who engaged in SIB maintained by access to materials. That is, for the NCR without EXT participant, reinforcers were delivered on a fixed-time schedule and following occurrences of the target behavior. If extinction was solely responsible for the decreased responding in the NCR plus extinction condition, NCR without extinction would not result in decreases in behavior. If decreases in responding were observed, satiation may be implicated as the mechanism contributing to NCR's success. Results showed that SIB decreased similarly in NCR without extinction for this one participant when compared to the NCR + EXT conditions implemented for other participants. Because no extinction component was in effect and behavior decreased, satiation seemed to be the mechanism of behavior change.

Results of Marcus and Vollmer (1996) and Lalli et al. (1997) seem to be contradictory. In the Marcus and Vollmer study, extinction was implicated as the mechanism through which NCR was effective. Lalli et al., on the other hand, implicated satiation as the mechanism through which NCR was effective. These results, while discrepant, may suggest that the mechanisms through which NCR is effective are idiosyncratic. For some individuals, satiation may take place when NCR is in effect, thus resulting in decreased responding. For others, the individual may still be highly motivated to receive the reinforcer but, due to the breakdown in the response-reinforcer relationship (i.e., extinction), responding decreases.

### **Finding 2: NCR reduces behavior more effectively than extinction**

Only one applied study has directly compared NCR and extinction. Vollmer et al. (1998) directly compared the effect of NCR and extinction (EXT) as treatment for the inappropriate behaviors of three individuals with developmental disabilities. During baseline, the reinforcer was delivered contingent on problem behavior on a FR 1 schedule. During treatment, FT and EXT were evaluated using a multielement design. In the FT condition, reinforcers were continuously available at the outset, but the FT interval was gradually increased to 5 minutes. In EXT, no reinforcers were delivered. For one individual, FT was more effective than EXT in reducing three separate inappropriate behaviors (SIB, tantrum, and disruption). For a second individual, FT was

more effective than EXT in reducing the amount of aggression exhibited. For the final participant, FT was more effective in some circumstances but not in others. Overall, results suggested that, when presented continuously at the outset of treatment, NCR was generally more effective than EXT in reducing problem behaviors.

The findings of applied NCR studies have at least two important implications: (a) behavior rates can be reduced by presenting reinforcers on a time-based schedule (NCR) and (b) behavior rates can be reduced almost immediately (in contrast to extinction) by presenting reinforcers on a continuous or near continuous basis independent of behavior at the outset of treatment. It is possible, however, that the often dramatic results of NCR may lead practitioners to recommend time-based reinforcement schedules without reference to baseline reinforcement rates. It is also possible, given the results of laboratory studies, that NCR effects are not as pronounced if the NCR schedule is similar to baseline in terms of reinforcer rates. To date, this baseline/NCR relationship has not been evaluated.

The relationship between baseline and NCR reinforcer rates has direct applied significance: A similarity between baseline and treatment reinforcer rates might decrease treatment efficacy. For example, suppose a child engaged in problem behavior and his or her parent provided attention (the reinforcer) for this behavior on average once every 5 minutes. If it was then recommended by a practitioner to provide attention on a noncontingent basis once every 5 minutes, there is a distinct possibility that the behavior would be maintained because the NCR schedule is similar to the baseline schedule of reinforcement.

## PURPOSE

In laboratory settings, NCR effects are not as pronounced as extinction effects. In applied research, NCR has been demonstrated to effectively reduce problem behaviors, apparently to a greater degree than extinction. It is possible that NCR effects in the laboratory are less pronounced because the reinforcer rate is very similar to the reinforcer rate in baseline. If this relationship holds true, the implications for NCR as treatment are twofold: 1) When NCR schedules are implemented as treatment, they may be ineffective, with no clear reason why, if the schedule implemented is intentionally or unintentionally similar to the baseline reinforcer rate. 2) If distinct schedules are demonstrated as effective to the exclusion of similar schedules, those results would indicate distinct schedules as the schedules of choice when using NCR as treatment. The present study addressed the apparently discrepant results of basic and applied research on NCR.

The main purpose of the current study was to evaluate whether behavior decreases more substantially when the FT reinforcer rate is similar or dissimilar to a baseline (response-dependent) reinforcer rate. During baseline, reinforcers were delivered following behavior either intermittently (lean schedule) or after every behavior (rich schedule). Response-dependent reinforcement is analogous to situations when problem behavior is inadvertently reinforced (strengthened) by parents or teachers who provide attention, toys, etc. During FT, response-independent reinforcers were delivered at a rate either higher than (dissimilar to), lower than (dissimilar to), or equated with (similar to) baseline. Note that response-independent reinforcers are noncontingent on behavior (NCR); they are presented on a time schedule whether or not behavior occurs. It was hypothesized NCR would reduce baseline response rates more effectively when NCR is dissimilar to baseline reinforcement rates.

## GENERAL METHOD

### Participants and Setting

Thirteen individuals were recruited to participate in the study. All participants were recruited from an inpatient unit at the Children's Seashore House, located on the campus of University of Pennsylvania in Philadelphia, PA. Each participant had been admitted for the assessment and treatment of severe behavior problems including self-injurious behavior (SIB), aggression, and tantrum behavior. Of the 13 individuals who participated, four passed the initial screening criteria for further participation (see Phase I). Sandie was a four-year-old girl admitted for assessment and treatment of tantrums and SIB. She had a hearing loss, but was otherwise typically developing. Her participation was abbreviated because she was discharged prior to completing the entire study. Her data are available upon request. Tami was a four-year-old girl admitted for assessment and treatment of tantrum and aggressive behavior. She had a speech deficit, and functioned in the moderate range of mental retardation. Jimmy was a five-year-old boy admitted for assessment and treatment of SIB and aggression. He was diagnosed with autism and functioned in the moderate to severe range of mental retardation. Cathi was a thirteen-year-old girl admitted for assessment and treatment of self-injurious and disruptive behavior and she functioned in the moderate to severe range of mental retardation. Each of the participants was ambulatory and possessed at least some functional verbal behavior.

Sessions took place in an empty room on the inpatient hospital unit. Two to eight five-minute sessions were conducted 4 to 7 days per week, depending on the patient's schedule (the exact procedures are described in greater detail in the "Procedure" section of each Phase). An experimenter was in the room along with a table, chairs, reinforcers (some conditions), and task materials. The room was equipped with a one-way mirror.

### **Apparatus**

Specific task materials in the room varied across participants. Task materials included microswitches, which varied in color depending on experimental condition and component; a slotted tray, colored blocks, and a placemat (of varying color, depending on condition and component); a placemat (of varying color, depending on condition and

component) and picture card; or worksheets (of varying color depending on condition and component).

### General Procedures

#### **Data collection**

Trained psychology interns and bachelor's level therapists served as observers. All observations were conducted from behind a one-way mirror. Observers used a computerized data collection procedure to record target behavior, reinforcer delivery, and collateral behaviors (e.g., aggression). The computer program allowed for data analysis on a second-by-second basis.

#### **Response measurement**

For all participants, a target behavior was individually defined. For Sandie, Jimmy, and Cathi, the target behavior was activating a microswitch. For Tami, the behavior was accurately sorting colored blocks. These behaviors were recorded as responses per minute. Reinforcer delivery was also recorded and reported as responses per minute.

Issues related to application have been studied in the laboratory using the methods employed in this study. Specifically, the behaviors chosen were of a nonclinical (i.e., arbitrary) nature. In their evaluation of reinforcer magnitude on FT-schedule performance, Carr, Bailey, Ecott, Lucker, and Weil (1998) used arbitrary behavior (dropping chips into a cylinder one at a time). Other studies have also used arbitrary behavior as a target response. For example, Vollmer and Iwata (1991) evaluated the effect of satiation and deprivation on behavior using such arbitrary behavior as placing blocks through a slot in the top of a bucket and activating a microswitch. By using nonclinical behavior as a target response, several potential problems are averted. Sessions do not need to be discontinued due to danger to the participant or therapist. Similarly, conditions that result in continued responding would not result in danger to the participant. Finally, a brief reinforcer demonstration can be conducted prior to the experiment rather than a lengthy assessment (i.e., a functional analysis).

**Interobserver agreement**

Two independent observers recorded data simultaneously but independently during at least 20% of all sessions. Agreement percentages were calculated based on interval-by-interval comparison of the observers' records, in which the smaller number of responses in each interval was divided by the larger number of responses. These fractions were then summed across all intervals and divided by the total number of intervals in the session to obtain the percentage agreement between the two observers. Interobserver agreement was collected during 23.8% of Tami's sessions. Agreement averaged 98% (range, 85%-100%) for the target response. For Jimmy, agreement was collected during 25.9% of all sessions. Agreement averaged 95.1% (range, 84% to 100%) for the target response. For Cathi, agreement was collected during 23.9% of all sessions. Agreement averaged 94.6% (range, 78%-100%) for the target response.

## PHASE I: REINFORCER ASSESSMENT

Phase I was conducted in order to demonstrate that the stimuli chosen to be presented were indeed reinforcers. If the stimuli did not serve as reinforcers, then the experimental questions could not be answered. Evidence that a stimulus is a reinforcer is obtained by evaluating two conditions: 1) no stimulus presentation (no reinforcement this Phase and extinction during Phase II) and 2) response-dependent stimulus presentation. Higher response rates during response-dependent stimulus presentation relative to no stimulus presentation would indicate the stimulus serves as a reinforcer. In previous parametric studies concerning NCR (e.g., Carr et al., 1998), this demonstration has been omitted. This omission can be seen as a limitation of previous studies.

### Procedure

Potential reinforcers were determined via verbal nomination, parent interview, or free-operant preference assessment (Roane, Vollmer, Ringdahl, & Marcus, 1998). Following a no-reinforcement baseline, the preferred stimuli were presented contingent on a target response (FR 1 schedule). For some participants, the reinforcement schedule was then changed to an intermittent (i.e., fixed-interval) schedule. Data were evaluated for a reinforcement effect (i.e., an elevation in responding during a response-dependent condition relative to responding during a no-reinforcement condition).

### **General arrangement**

The participant was brought into the experimental room and offered a seat. Work materials were placed in front of him or her, and he or she was instructed as follows: "Here is a task to work on; you may do as much as you want, as little as you want, or none at all." The participant was then allowed to engage in the task for 5 minutes. At the end of the 5-minute session, the therapist told the participant he or she was done. This procedure was followed for each of the conditions.

### **No-reinforcement baseline**

Following the instruction, there was no interaction between the therapist and the participant. No programmed consequence for task engagement was delivered. At the end of the five-minute session, the therapist told the participant that he or she was done working. Once stable responding was observed across sessions, a response-dependent

baseline was conducted. The purpose of the no-reinforcement baseline condition was to observe the participants' behavior when no contingency was programmed.

### **Response-dependent baseline**

Following the instruction, the therapist provided reinforcers (as identified in the preference assessment) on a fixed-ratio (FR) 1 schedule. Thus, following each correct response, a reinforcer was given to the participant. At the end of the five-minute session, the therapist told the participant that he or she was done working. The participant continued to Phase II if this condition resulted in an increase in behavior relative to the previous no-reinforcement baseline (i.e., a reinforcement effect). The purpose of the response-dependent reinforcement baseline was to evaluate whether an effective reinforcer for the experimental task was identified. Reinforcers assessed included edibles (e.g., chips or small candy) and praise.

### **Experimental design**

A multiple baseline design was used to evaluate reinforcement effects. In addition, for Jimmy and Sandie, the microswitch color alternated (either yellow or blue) to control for color preferences. For Tami, different color placemats (black or white) were set under the task materials depending on the session.

### **Results and Discussion**

Figure 1 displays the results of the reinforcer assessments for the four individuals for whom reinforcement effects were observed. The top panel displays the results of Jimmy's reinforcer assessment. Responding was initially elevated during the first session of the blue component (i.e., when the blue microswitch was available) of the multiple schedule (closed circles), but decreased across the remaining no-reinforcement sessions. Mean response rates during the response-dependent baselines were slightly elevated when compared to response rates during the no-reinforcement baselines. However, within-session analysis (not depicted in the figure) suggested a reinforcement effect because responding decreased across minutes during the no-reinforcement baseline sessions and increased or remained elevated and stable across minutes during the response-dependent baseline sessions.



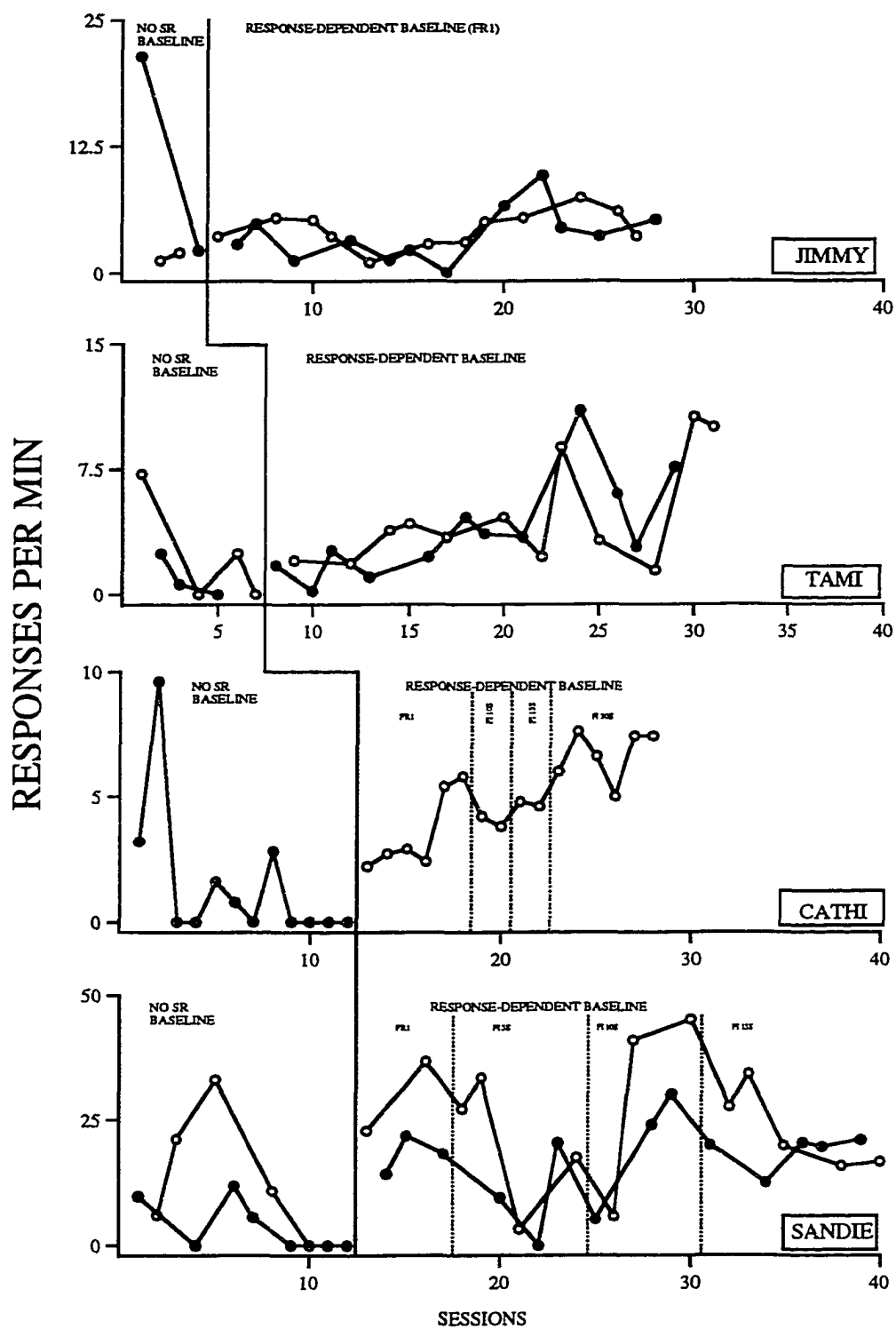


FIGURE 1. Responses per minute during no-reinforcement and response-dependent baselines.

The second panel of Figure 1 displays the results of Tami's reinforcer assessment. A downward trend in responding was exhibited during each component of the no-reinforcement baseline. Responding averaged .8 responses per minute during the last three sessions of the white component (i.e., when a white placemat was placed under task materials; open circles) and 1 response per minute during the three sessions of the black component (i.e., when a black placemat was placed under task materials; closed circles). During the response-dependent baseline (FR 1), responding averaged 2.1 responses per minute (last three white) and 2.3 responses per minute (last three black).

The third panel displays the results of Cathi's reinforcer assessment. Cathi initially responded during the no-reinforcement baseline. However, after 8 sessions, response rates were 0 responses per minute. During the FR 1 baseline, responding immediately increased. During the seventh session of the response-dependent baseline, the reinforcement schedule was changed to an intermittent schedule (beginning at FI 10 seconds and terminating at FI 30 seconds). Responding averaged 6.6 responses per minute during the last three FI-30 second sessions.

The final panel displays the results of Sandie's reinforcer assessment. Responding during both components of the no-reinforcement baseline reached 0 responses per minute after 8 sessions. During the FR 1 baseline, responding averaged 20.3 responses per minute during the last three sessions of the blue component (closed circles) and 19.4 responses per minute during the last three sessions of the yellow component (open circles).

The other nine participants were not selected for further participation because no reinforcement effect was obtained. Figure 2 depicts representative outcomes for individuals who did not display a reinforcement effect. For Darwin (top panel), responding decreased across no-reinforcement baseline sessions, eventually reaching 0 responses per minute. During the response-dependent baseline, responding was initially elevated relative to the previous baseline. However, responding continued on a downward trend across sessions eventually reaching 0 responses per minute. For Sean (middle panel), responding was at or near 0 responses per minute throughout the no-reinforcement baseline. When the response-dependent baseline was implemented,

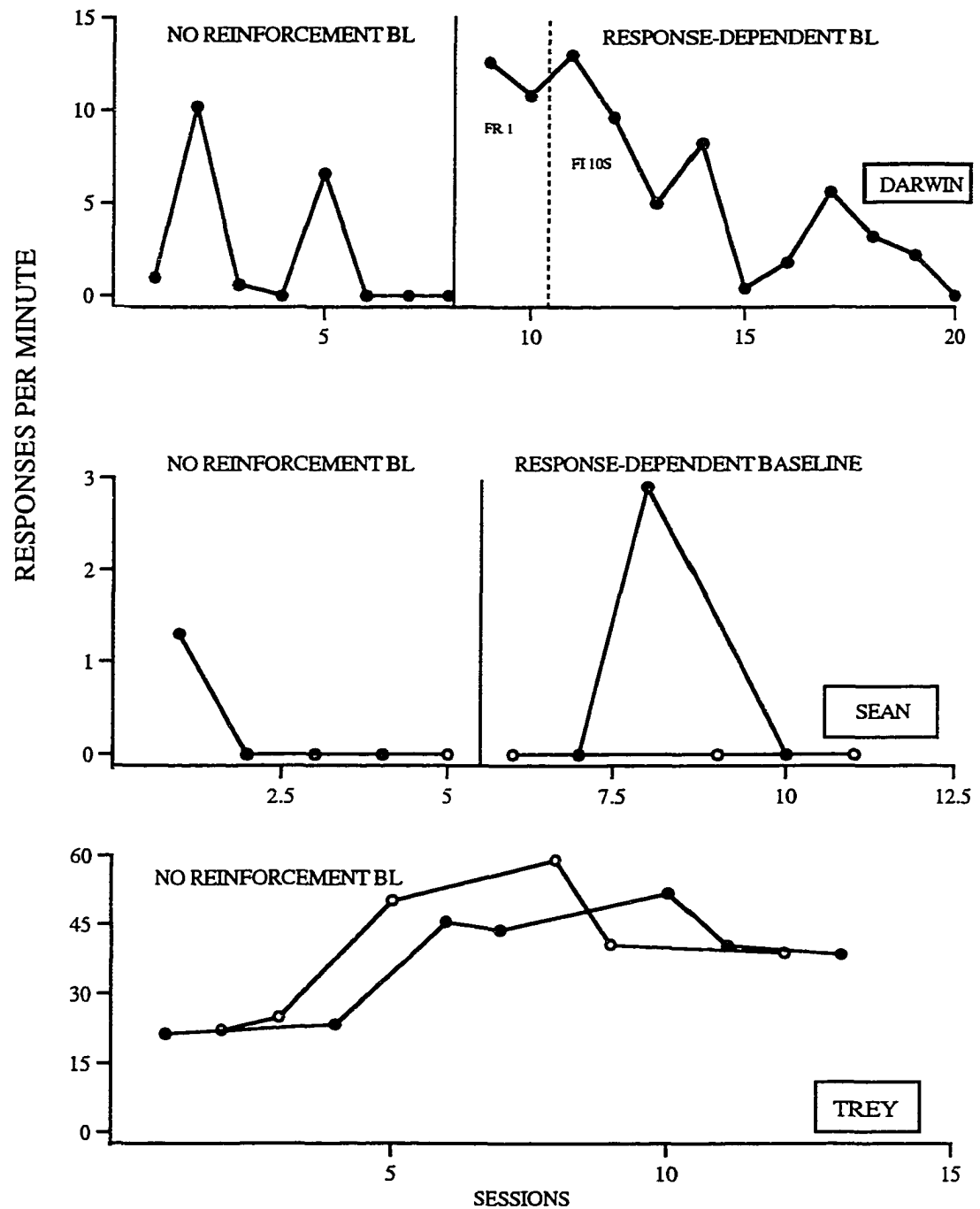


FIGURE 2. Responses per minute during no-reinforcement and response-dependent baselines

responding remained at or near 0 responses per minute. For Trey, responding occurred at a high level (average=38.5 responses per minute across all sessions). For Trey, no response-dependent baseline was implemented because it would have been difficult for his behavior to increase. For Darwin and Sean, the chosen stimuli did not serve as reinforcers. It may have been possible to identify other reinforcing stimuli, but all participants were on the inpatient unit for limited time periods. For Trey, no response-dependent baseline was implemented because his behavior was already occurring at a high level, indicating that the behavior was maintained by some other reinforcer or was under instructional control. In addition, including three to four participants in Phase II was viewed as compatible with other previously reported single-subject design studies on response-independent reinforcement (e.g., Carr et al., 1998; Vollmer et al., 1993).

## PHASE II: FIXED-TIME ANALYSES

Recall that there is evidence in the basic literature to suggest extinction schedules result in consistently greater response suppression than FT schedules. However, Vollmer et al. (1998) presented evidence suggesting FT schedules may reduce behavior more effectively than extinction. One possible explanation for these divergent conclusions may be the relationship between the response-dependent reinforcer rates and the FT reinforcer rates. Specifically, behavior may be less likely to decrease if the baseline and FT reinforcer rates are similar. This hypothesis was investigated during Phase II. The effects of similar-FT schedules, dissimilar-FT schedules, and extinction were evaluated. If higher response rates are seen during FT similar (in comparison to FT dissimilar and extinction), it suggests the similarity between FI and FT schedules may make behavior more resistant to change.

### Procedure

The same experimental preparation used in Phase I was used during Phase II.

### Baseline conditions

#### **Rich baseline**

Following the demonstration of reinforcer effectiveness (see Phase I), Tami and Jimmy received reinforcers on a “rich” schedule (FR 1). Following the initial instruction, the therapist provided the reinforcers on a FR-1 schedule. At the end of a five-minute session, the therapist told the participant that he or she was done working. Once stable responding was observed across sessions, the experimental conditions were conducted. The rich-baseline condition was analogous to the baseline conditions described in many treatment studies, in which each occurrence of the target behavior resulted in reinforcer delivery (see, Vollmer, Marcus, Ringdahl, & Roane, 1995).

#### **Lean baseline**

Following demonstration of reinforcer effectiveness, Cathi’s behavior was maintained on a “lean” or intermittent reinforcement schedule. Following the initial instruction, the first response following 30 seconds was reinforced (FI 30 seconds) throughout the 5-minute session. At the end of the session, the therapist told Cathi she was done working. Once stable responding was observed across sessions, the

experimental conditions were conducted. The lean baseline condition was analogous to the baseline conditions described in many laboratory studies (see, Rescorla & Skucy, 1969) and intermittent schedules sometimes maintain problem behavior in the natural environment (Lerman & Iwata, 1993).

#### Experimental conditions

##### **Extinction**

In this condition, no reinforcers were available. Following the prompt to work, no reinforcers were presented, regardless of the participants' behavior. The purpose of the extinction condition was to provide a comparison to the fixed-time (FT) conditions. Also, decreased responding in this condition would confirm that the target response was in fact maintained by the reinforcer used in the experiment.

##### **Fixed-time similar**

This condition was designed to evaluate FT schedule effects when the programmed reinforcer rate was similar to that achieved during the preceding response-dependent baseline. Following the prompt to work, the therapist provided a reinforcer independent of responding at a rate yoked to the previous baseline schedule. For example, if the schedule in the previous condition was FR 1 (rich), the FT similar schedule was based on the reinforcer rate achieved during the last 5 sessions. If, on average, 3 reinforcers per minute were delivered, the schedule during FT similar was FT 20 seconds. If the schedule in the previous condition was intermittent (lean), for example FI 30 seconds, the schedule during FT similar was FT 30 seconds.

##### **Fixed-time dissimilar**

This condition was designed to evaluate FT schedule effects when reinforcers were delivered either more or less frequently than during the preceding response-dependent baseline. Following the prompt to work, the therapist provided a reinforcer independent of responding on a schedule dissimilar to the previous condition's schedule. Reinforcer rates were assigned by either multiplying or dividing baseline rates by six. For example, if the baseline schedule in the previous condition was FR 1 (rich) as described earlier and yielded one reinforcer every 20 seconds, the FT dissimilar schedule could have been FT 120 seconds. If the schedule in the previous condition was

intermittent (lean), for example FI 30 seconds , the schedule during FT dissimilar could be FT 5 seconds, setting up a relatively richer reinforcer schedule.

### Experimental designs

Fixed-time schedules and Extinction were evaluated using a combination of multielement and reversal designs (the particular designs employed varied across participants). When a multielement design was used, each component of the various phases was correlated with a unique stimulus (e.g., color of microswitch).

For Tami, a combination multielement and reversal design (ABACAD; A=baseline [FR 1 versus FR 1]; B=FT dissimilar [180 seconds] versus extinction; C=FT similar [20 seconds] versus extinction; D=FT similar [20 seconds] versus FT dissimilar [90 seconds]) was used to evaluate the effects of FT-similar, FT-dissimilar, and extinction schedules. For Jimmy, a combination multielement and reversal design was initially used to evaluate the effects of FT-similar, FT-dissimilar, and extinction schedules. However, the design was changed to an ABCBCACADAD reversal design (A=baseline [FR 1]; B=extinction; C=FT similar [10 seconds ]; and D=FT dissimilar [40 seconds]) to aid in discrimination. For Cathi, an ABABACAC reversal and multielement design was used to investigate the schedule effects (A=baseline [FI 30 seconds]; B=FT dissimilar [5 seconds]; C=FT similar[30 seconds]). In the final experimental condition for Cathi (C), a FT-dissimilar schedule was added. Thus, this experimental condition compared the effects of FT-similar and FT-dissimilar schedules using an multielement design (as described previously).

### Results and discussion

Figure 3 displays the results of the FT analysis for Tami. Following a response-dependent reinforcer baseline, the effects of FT dissimilar and extinction were compared. Responding during the initial response-dependent baselines was reinforced on a FR 1 schedule. Rates averaged 1.5 responses per minute during the white component (open circles) and 2.1 responses per minute during the black component (closed circles). Following the response-dependent baseline, a FT-dissimilar (FT 180 seconds) schedule and extinction were implemented. Responding decreased during both components (mean=.5 responses per minute during the last five sessions of FT dissimilar and mean=

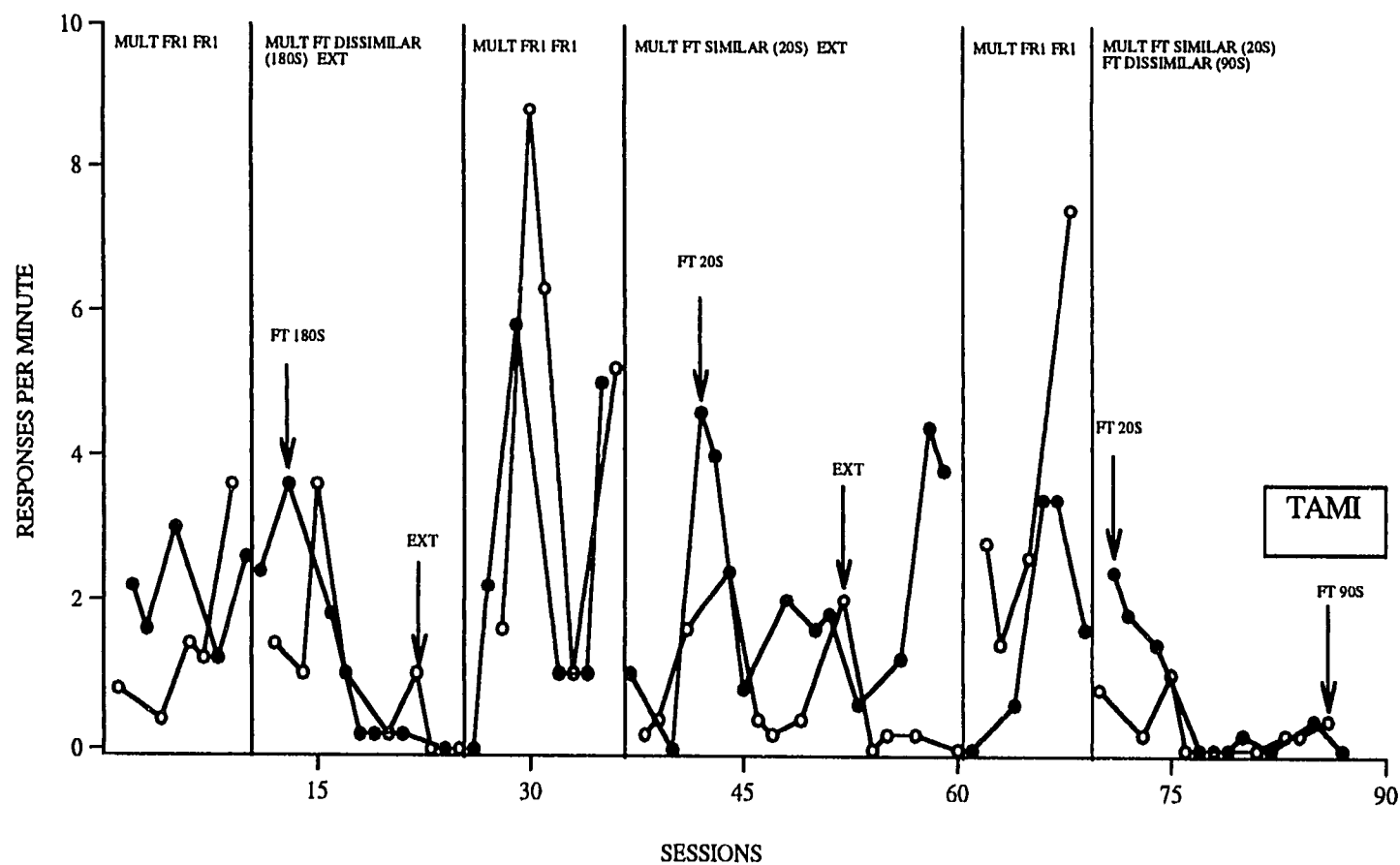


FIGURE 3. Responses per minute during response-dependent baseline, FT dissimilar/extinction, FT similar/extinction, and FT similar/FT dissimilar



.4 responses per minute during the last five sessions of extinction). In both components, rates eventually reached 0 responses per minute. In addition, the degree to which responding decreased from baseline was almost equivalent (76% decrease during FT dissimilar, 73% decrease during extinction based on the averages of the last five sessions in each component).

Following a reversal to a second response-dependent reinforcer baseline, the effects of FT similar and extinction were compared. Initially, responding was variable during both schedules. During the last five session of FT similar, responding averaged 2.4 responses per minute, while responding during the last five sessions of extinction averaged .5 responses per minute. When compared to the preceding response-dependent reinforcer baseline, these rates represent a 20% decrease during FT similar and 89% decrease during extinction (compared to 76% reduction during FT dissimilar). Following another reversal to a response-dependent reinforcer baseline, FT similar and FT dissimilar were directly compared. Responding in both schedules decreased to near zero levels (.12 responses per minute during the last five sessions of FT similar; .16 responses per minute during the last five sessions of FT dissimilar). However, responding during the FT dissimilar schedule was lower at the outset. To summarize, when FT similar and dissimilar were compared to extinction, FT dissimilar resulted in larger response decrements compared to FT similar (76% versus 20%). When compared directly, both FT similar and FT dissimilar resulted in near zero responding, but the average reduction in the first five sessions was 39% during FT similar versus 86% during FT dissimilar. Thus, overall, FT dissimilar reduced response rates to a greater degree than FT similar.

Figure 4 displays the result of the multielement FT analysis for Jimmy. Following a response-dependent baseline condition, the effects of extinction and FT similar on responding were evaluated. During the initial response-dependent baselines, responding averaged 5.5 responses per minute (yellow component) and 5.9 responses per minute (blue component). When FT similar (10 seconds) and extinction schedules were presented in an alternating fashion, responding decreased for both. During the last five sessions of FT similar, responding averaged 2.3 responses per minute. During the

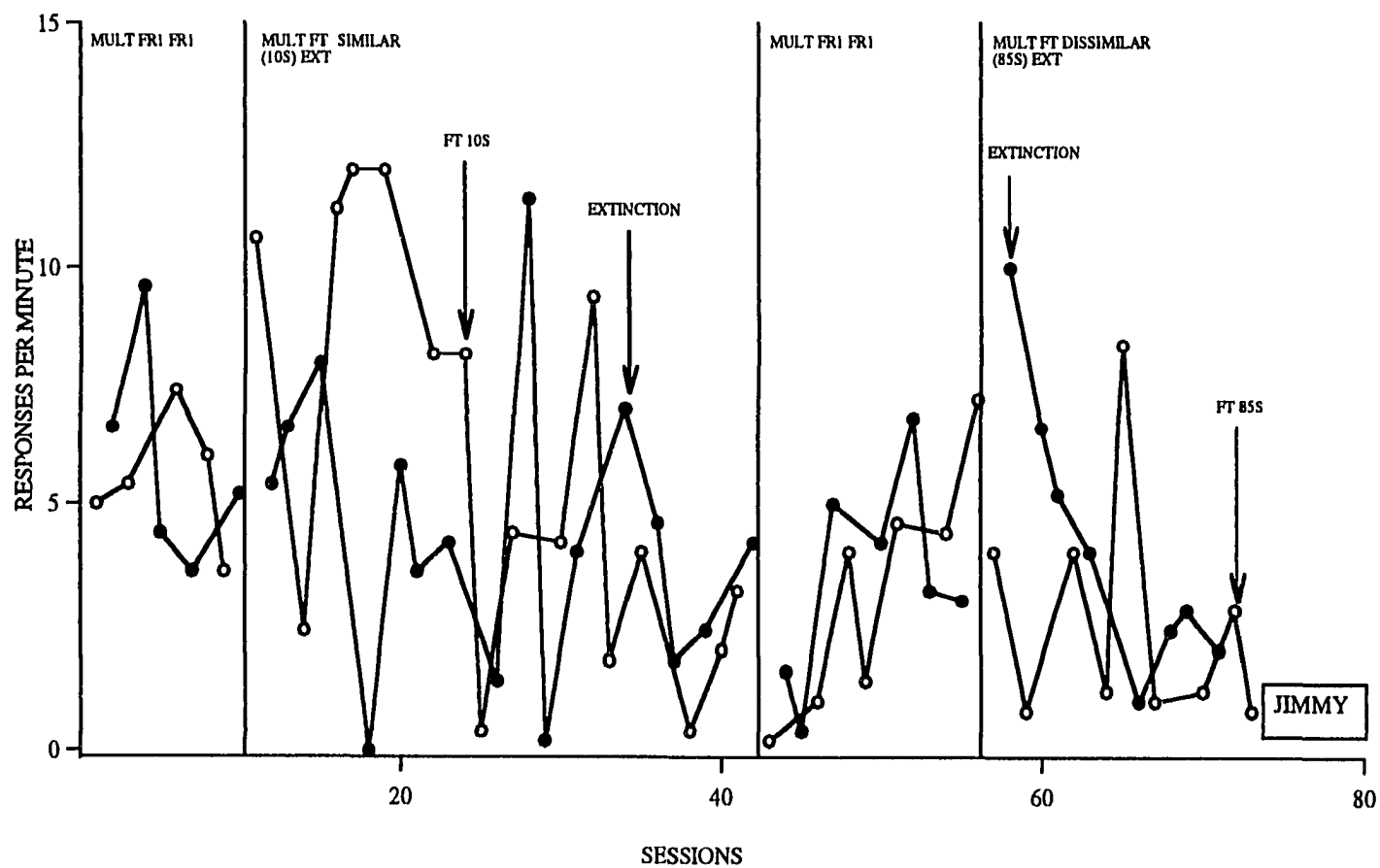


FIGURE 4. Responses per minute during response-dependent baseline, FT similar/extinction, and FT dissimilar/extinction.

last five sessions of extinction, responding averaged 4.0 responses per minute (a 58% and 32% decrease respectively). However, the high level of responding during extinction indicated that there may have been some interaction between the two schedules. Or, it is possible the behavior was now being maintained independent of the food reinforcer (i.e., automatic reinforcement or instructional control). The effects of FT dissimilar and extinction were then compared. Responding averaged 4.3 responses per minute during the last five sessions of the yellow baseline (open circles) and 4.4 responses per minute during the last five sessions of the blue baseline (closed circles). During both FT dissimilar (85 seconds) and extinction, responding decreased. During FT dissimilar, responding averaged 2.4 responses per minute during the last five sessions. During the last five sessions of extinction, responding averaged 2.8 responses per minute but was on a downward trend. However, within-session patterns showed that the behavior was not extinguishing. For Jimmy, the degree of reduction during extinction (45%) was greater than during FT dissimilar (35%). Due to the sustained responding during extinction, these results again indicated possible interaction between the two schedules, or that behavior was not being maintained by the food reinforcer.

In order to control for interaction effects, and to ensure that behavior would extinguish, the schedules were evaluated using a reversal design. Figure 5 displays the results of this analysis. The most recent response-dependent baseline is included on the figure to provide a reference for response levels. During the first extinction phase, rates dropped to 0 responses per minute (mean=.4 responses per minute during the last five sessions). During the FT similar (10 seconds) phase, responding reemerged (mean=3.1 responses per minute during the last five sessions) despite the absence of a programmed reinforcement contingency. Extinction was then reimplemented and rates again dropped to 0 responses per minute (mean=.6 responses per minute). During the last five sessions of the following reversal to FT similar, rates averaged 3.3 responses per minute. A new response-dependent baseline was then conducted (mean=6.1 responses per minute during the last five sessions). Fixed-time similar (10 seconds) was again implemented and rates increased across four sessions (mean=12.7 responses per minute). During the last five sessions of the following FR 1 schedule, rates averaged 9.2 responses per minute. A

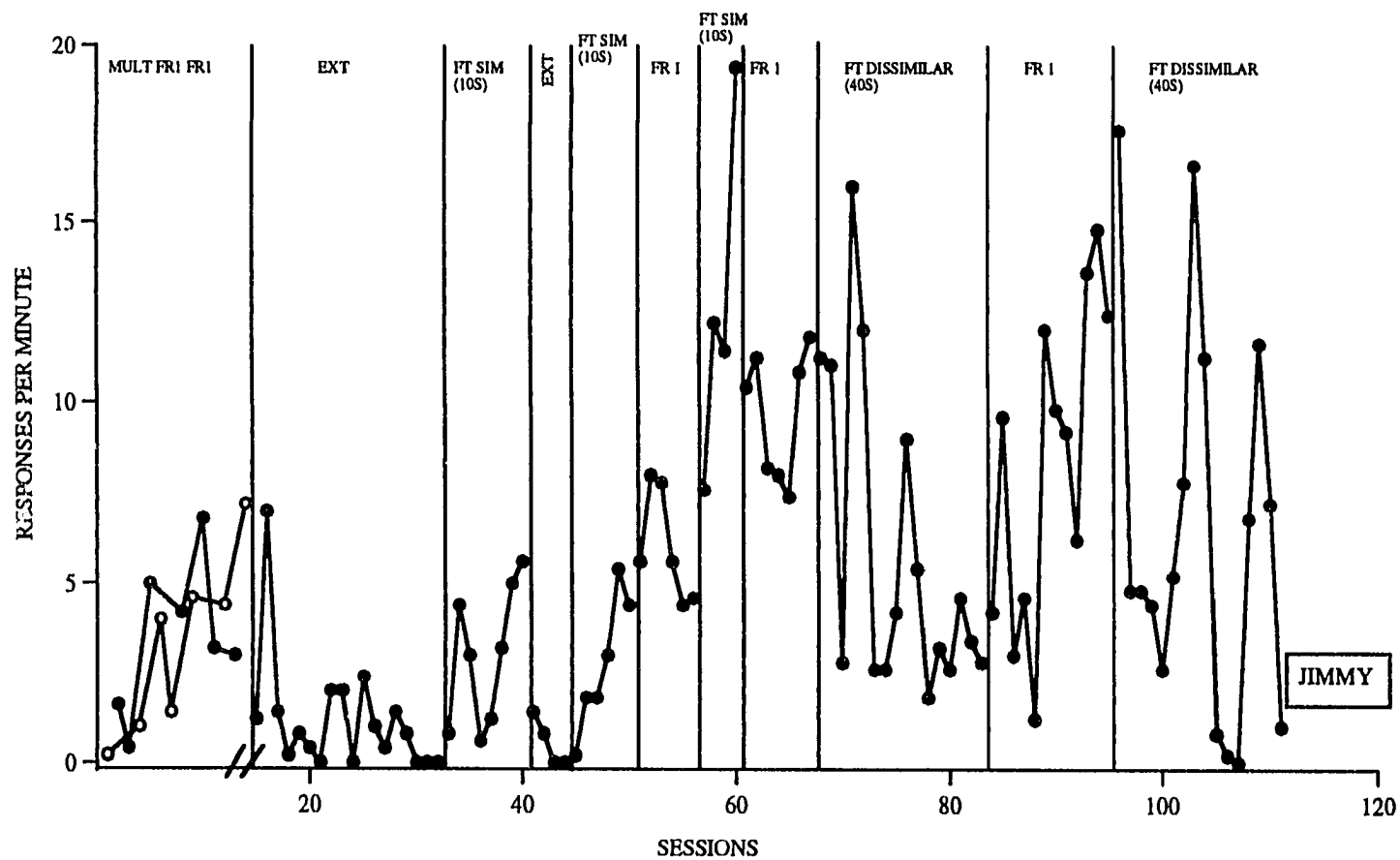


FIGURE 5. Responses per minute during response-dependent baseline, extinction, FT similar, and FT dissimilar.

FT-dissimilar schedule was then implemented (FT 40 seconds). Rates during this condition averaged 3.1 responses per minute (a 66% response decrement). A FR 1 schedule was then reimplemented. During the last five sessions of this condition, rates averaged 11.2 responses per minute. A FT-dissimilar schedule (FT 40 seconds) was again implemented. Responding during this condition was highly variable compared to the earlier FT-dissimilar condition. However, mean response rates were decreased relative to the previous response-dependent baseline (mean=5.3 responses per minute during the last 5 sessions, a decrease of 53%). For Jimmy, when the various schedules were presented in a reversal fashion, rates decreased in extinction (88.5% reduction) and FT dissimilar (60%). Overall, response rates were actually higher during the FT-similar schedule (by 50.3%) than during response-dependent baselines. Thus, these results are similar to Tami's insofar as FT-similar schedules did not decrease responding as effectively as FT dissimilar.

These results are important as they indicate lean FT schedules can effectively reduce behavior. Previously, Hagopian et al. (1994) demonstrated that lean FT schedules were not as effective as dense FT schedules (at least initially). However, the lean schedules in that investigation were based on the previous Vollmer et al. (1993) evaluation and were not based on baseline reinforcer rate. The results of this analysis indicate that lean FT schedules can be effective (in fact, more effective than denser FT schedules) when they are based on baseline reinforcer rate.

Figure 6 displays the results of the fixed-time analysis for Cathi. The effects of FT dissimilar (FT 5 seconds; relatively rich) and FT similar (FT 30 seconds) were compared using an ABABACAC reversal design. Responding during the initial response-dependent baseline was reinforced on an intermittent schedule (FI 30 seconds). Rates averaged 6.8 responses per minute during the last 5 response-dependent-baseline sessions. Responding during the first FT-dissimilar (FT 5 seconds) condition was initially similar to that of the previous baseline. However, responding decreased across sessions. During the last five sessions of the condition, rates averaged 1.7 responses per minute (a 75% decrease from baseline). After a reversal to a response-dependent baseline (FI 30 seconds; mean=8.9 responses per minute), the FT-dissimilar schedule was

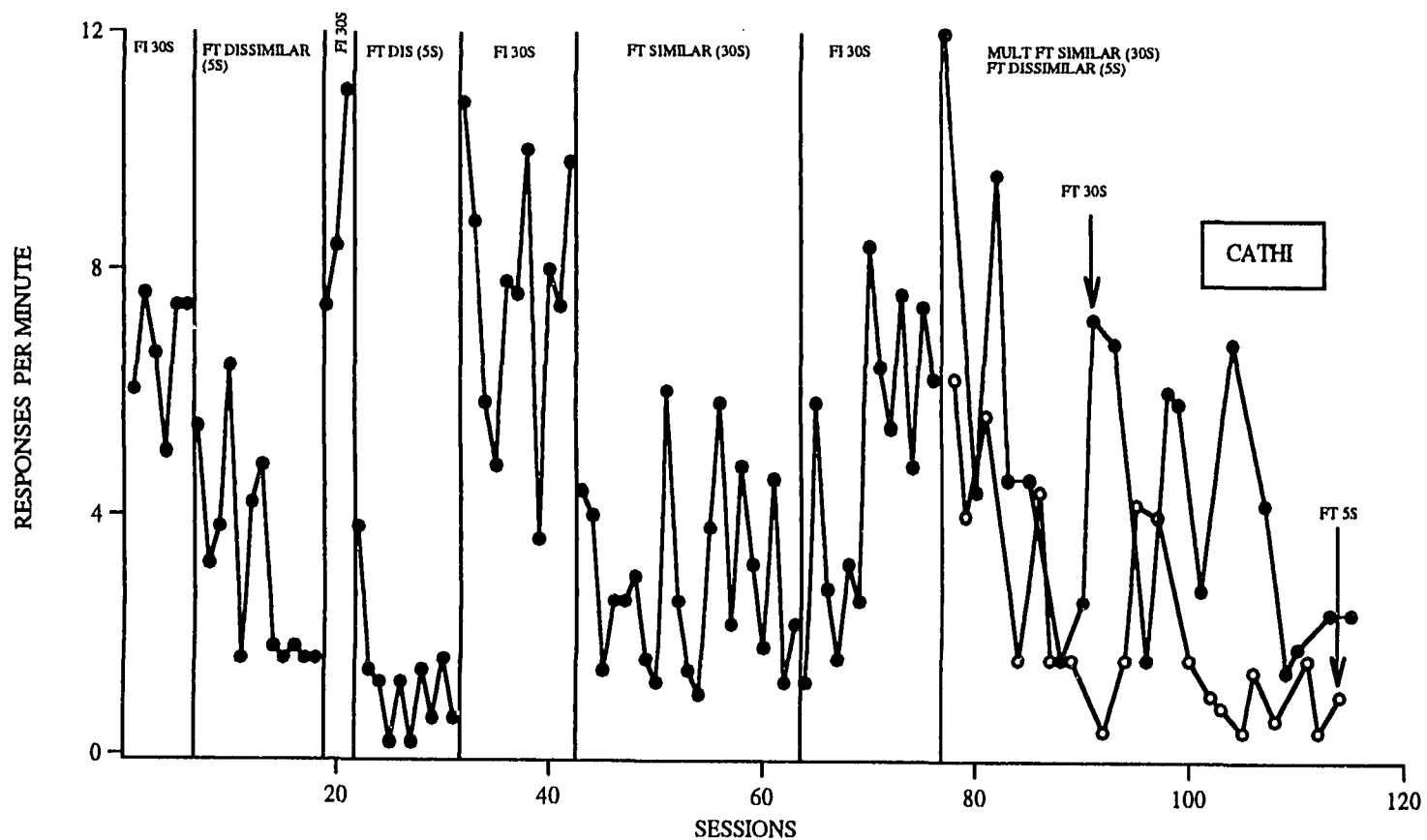


FIGURE 6. Responses per minute during response-dependent baseline, FT dissimilar, FT dissimilar, and FT similar/FT dissimilar.

reimplemented. Rates decreased again, averaging .9 responses per minute during the last 5 sessions, a decrease of 90% from baseline. Following another reversal to FI 30 seconds (mean=7.8 responses per minute), a FT 30-second (similar) schedule was implemented. Responding was highly variable and decreased relative to the previous response-dependent baseline (mean=2.6 responses per minute during last five sessions, a 67% decrease). However, response rates during FT similar were higher than during FT dissimilar (2.6 responses per minute vs 1.3 responses per minute). Following another reversal to baseline (mean=6.3 responses per minute during last five sessions), the effects of FT similar (FT 30 seconds) and FT dissimilar (FT 5 seconds) were compared using a multielement design. Responding decreased across both conditions. However, similar to the prior conditions, rates during the FT-dissimilar schedule (1.0 responses per minute during last five sessions, an 84% decrease) were reduced to a greater extent than during the FT-similar schedule (2.4 responses per minute during last five sessions, a 62% decrease). For Cathi, the implementation of a FT schedules resulted in decreased responding (though not to zero). However, the implementation of FT-dissimilar schedules resulted in larger response decreases (mean=84%) compared with FT-similar schedules (mean=65%).

## DISCUSSION

In this study, the relationship between response-dependent baselines and FT schedules was evaluated. When FT schedules were similar to baseline reinforcer rates, response rates did not decrease as much as when FT schedules were dissimilar to baseline. In addition, for two participants, the response decrement during extinction was greater than any response decrement during FT similar but roughly equal to FT-dissimilar schedules. These results suggest that schedule transitions from baseline to treatment are important considerations.

Hagopian et al. (1994) presented evidence that “lean” FT schedules were not effective in reducing problem behavior. It is interesting to note that for two of the participants FT-dissimilar schedules were more “effective” even though the schedule was much leaner (i.e., 6 times) than the FT-similar schedule. This result cannot be accounted for with a “satiation” interpretation. A “satiation” interpretation would hold that, due to repeated delivery, the participants’ responding was reduced because the reinforcers had lost efficacy. However, the results of this study are not consistent with a satiation interpretation because relatively more responding occurred during a richer schedule (i.e., FT similar). If decreases in responding were a function of repeated reinforcer presentation (i.e., satiation), fewer responses should have been observed during the FT-similar schedules.

The results of this study also address one possible reason for the discrepancy between prior studies on NCR. Specifically, when reinforcers were delivered at similar rates during both a response-dependent baseline and FT, behavior did not decrease to the same extent as when reinforcers were delivered at different rates during a response-dependent baseline and FT. The reason(s) for the observed relationship between baseline and FT schedules is unclear. It may be that, when FT schedules are dissimilar to baseline schedules, responding decreases due to extinction (i.e., a disruption of the response-reinforcer relationship) or satiation. However, when FT schedules are similar, responding may continue for any of several reasons including incidental reinforcement and/or stimulus properties of the reinforcer (these hypotheses will be evaluated later).



The fact that behavior responds differentially to different FT schedules has direct implications for treatment: If a practitioner recommends the use of NCR to a parent of a child with a problem behavior without first knowing the existing reinforcement schedule for that behavior, problem behavior may inadvertently be maintained or strengthened as a result of schedule similarity. The results of this study suggest that the practitioner should take steps to ensure a discrepancy between baseline and treatment reinforcement schedules exists. This process might entail obtaining baseline reinforcement rates through naturalistic observation. Fixed-time schedules could then be generated resulting in relatively more or less reinforcer delivery relative to baseline. A second approach would be to use an obviously discrepant schedule (e.g., continuous reinforcement) at the treatment outset.

Two general factors may account for the observed differences between FT similar and FT dissimilar: First, during FT-similar schedules, a stimulus-response relationship may have emerged. That is, it is possible that reinforcer deliveries may have prompted the participant to respond. Evidence for such a stimulus-response relationship was presented by Uhl and Garcia (1969), who showed that, when compared to DRO, extinction produced more rapid reductions in lever pressing in rats. An analysis of stimulus-response relations during DRO showed that lever presses tended to occur almost immediately after food was delivered. In a sense, food “prompted” a lever press, even though lever pressing had no effect. In the current study, it is possible that reinforcers prompted responding because, previously, reinforcers were correlated with a reinforcement contingency (i.e., a discriminative stimulus effect).

A second possibility is that an incidental response-stimulus relationship developed. That is, it is possible that reinforcers were delivered (albeit coincidentally) more often following responding than following no responding, resulting in an unplanned contingency (Hammond, 1980).

To test the possibility of discriminative stimuli and incidental reinforcement effects, an evaluation of stimulus-response and response-stimulus contingencies was conducted. For each participant, the probability that a stimulus was followed by a response was compared to the stimulus-independent probability of a response. A

stimulus followed by a response was defined as a stimulus that was followed by response within a specified time frame (e.g., 3, 6, or 9 seconds). These probabilities were then linearly plotted. A stimulus-response contingency would exist if responding was more likely following stimulus delivery than stimulus-independent responding. Such a relationship would indicate a discriminative-stimulus effect. This relationship would be evident from the graph if the line representing the probability of a response given a stimulus was elevated relative to the line representing the stimulus-independent probability of a response.

Figure 7 displays the results of Cathi's stimulus-response analysis. The top panel displays the results of the analysis at the 6-second analysis level. During the initial FT-similar schedule (FT 30 seconds), the average stimulus-independent probability (P1; represented by the open circles) of a response during any 6-second window was .19. The average probability (P2; represented by the closed circles) that a stimulus was followed by a response during any 6-second window was .1. Similarly, during the second FT similar condition (second panel), P1 was .3 while P2 was .17. In both cases, visual inspection of the data paths as well as comparison of the means indicated no stimulus-response contingency was in place. That is, the delivery of a stimulus (i.e., reinforcer) did not result in an increased response likelihood. As the analysis window was increased (from 6 to 9 seconds), a discrepancy between the two probabilities remained intact. When the analysis window was 9 seconds (third and fourth panels),  $P1=.13$  during the first FT-similar evaluation while  $P2=.25$ . During the second FT-similar evaluation (FT 30 seconds),  $P1=.26$  while  $P2=.39$ . Thus, P2 was always greater than P1, discounting a stimulus-response relationship. In fact, the delivery of a stimulus actually decreased the likelihood of a response, suggesting Cathi paused after reinforcers were delivered. These results were similar across all participants and therefore, stimulus-response interpretations are ruled out.

The second possible hypothesis (presence of a response-stimulus contingency) was also evaluated. For each participant, the probability that a response was followed by a stimulus (i.e., a reinforcer) was compared to the response-independent probability of a reinforcer. A response followed by a stimulus was defined as a response that was

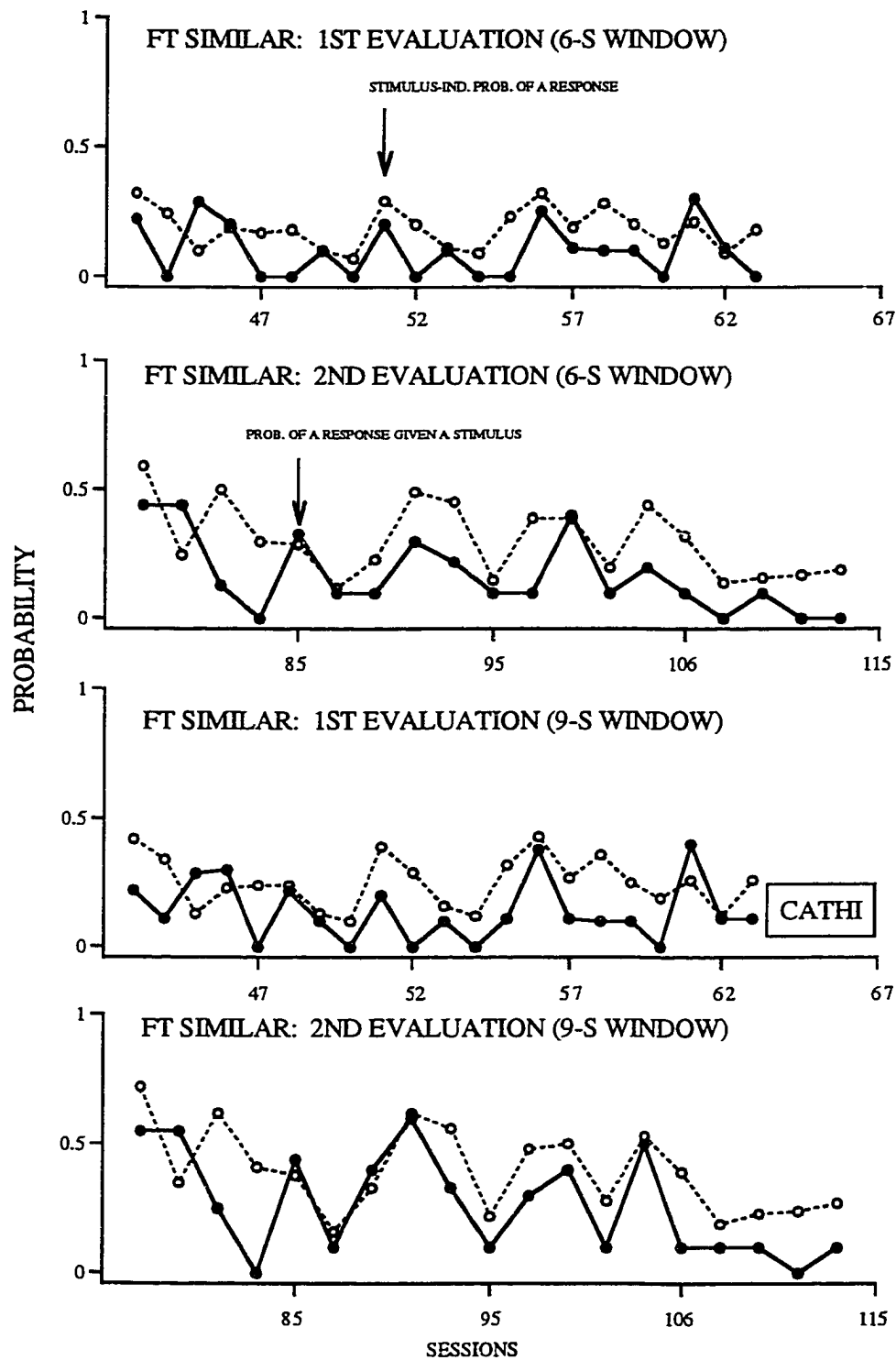


FIGURE 7. Stimulus-independent probability of a response and probability of response given a stimulus (within 6 and 9 seconds) during FT similar.

followed by a reinforcer within a specified time frame. For each participant, three separate time frames were arbitrarily chosen for investigation (3, 6, and 9 seconds). These probabilities were then plotted linearly. A response-stimulus contingency (albeit incidental) would exist if a stimulus delivery was more “probable” following a response than the response-independent delivery of a stimulus. This relationship would be evident from the graph if the line representing the probability of a stimulus given a response was elevated relative to the line representing the response-independent probability of a reinforcer.

Figure 8 displays the the results of the response-stimulus analysis for Cathi. The top panel displays the results of the 6-second analysis. During the initial FT-similar schedule, the response-independent probability (P1; represented by the open circles) of reinforcer delivery during any 6-second window was .18. The probability (P2; represented by the closed circles) that a response was followed by a reinforcer was .25. During the second FT similar evaluation (second panel), P1 was again .18 while P2 was .25. In both cases, visual inspection of the data paths as well as comparison of the means indicated a response-stimulus contingency was in place. That is, responding was associated with an increase probability of reinforcer delivery. The third and fourth panels display the results of the 9-second analysis. Again, for this analysis, P2 was greater than P1, indicating an incidental contingency. During the first FT-similar evaluation,  $P1=.28$  while  $P2=.35$ . During the second FT-similar evaluation,  $P1=.29$  while  $P2=.38$ .

While these results may explain why Cathi continued to respond during the FT-similar schedules, they were not consistent across participants. For example, figures 9 and 10 display the results of representative stimulus-response and response-stimulus analyses for Jimmy. Figure 9 displays the stimulus-response analysis using a three-second window. The average for P1 (stimulus-independent probability of a response; open circles) across all FT-similar sessions was .20 while the average for P2 (probability of a response given an stimulus; closed circles) across all FT-similar sessions was .15. Thus, no stimulus-response contingency was apparent. The bottom panel displays the response-stimulus analysis also using a 3-second window. The average for P1 (response-independent probability of a stimulus; open circles) across all FT-similar

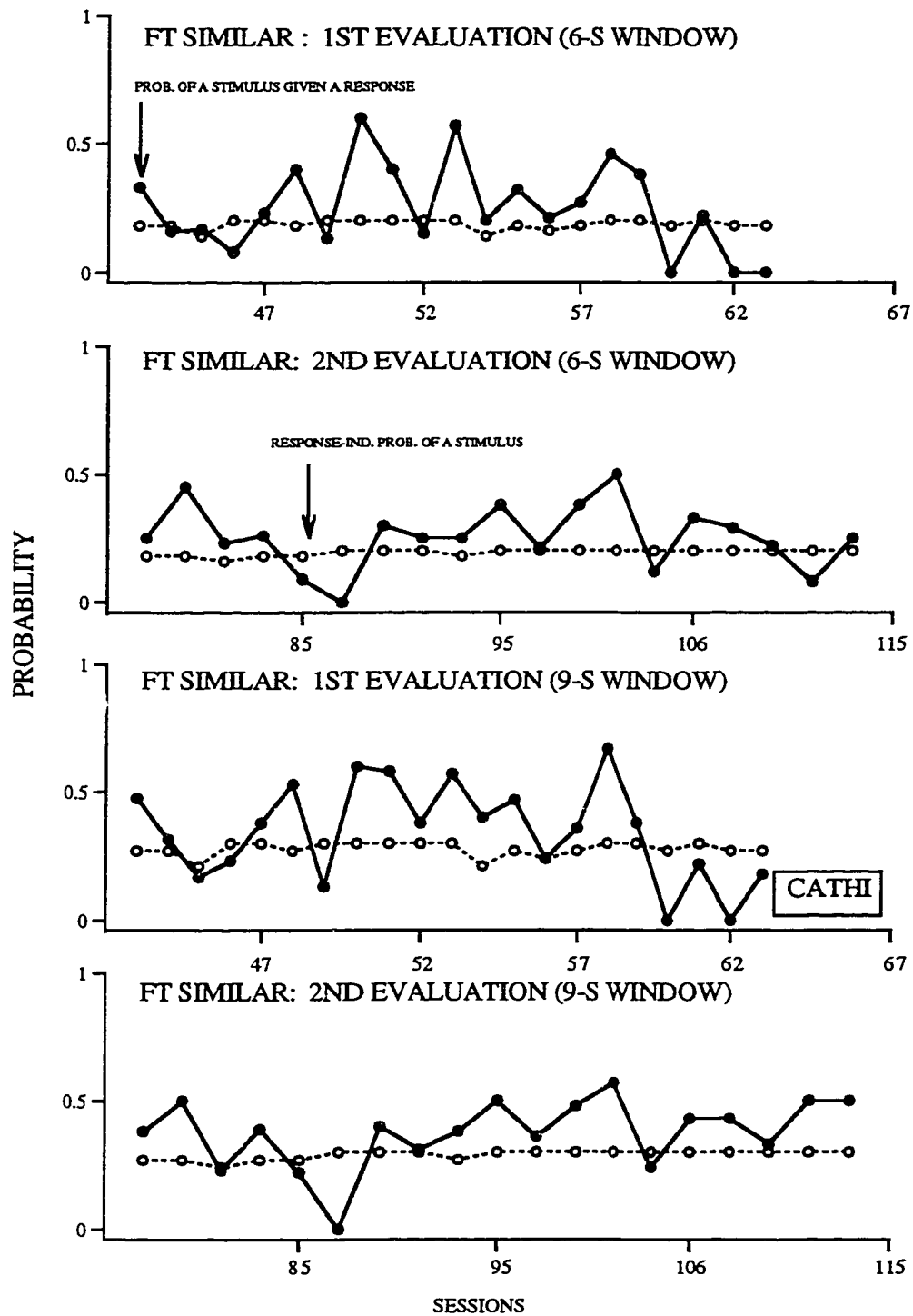


FIGURE 8. Response-independent probability of a stimulus and probability of a stimulus given a response (within 6 and 9 seconds) during FT similar.

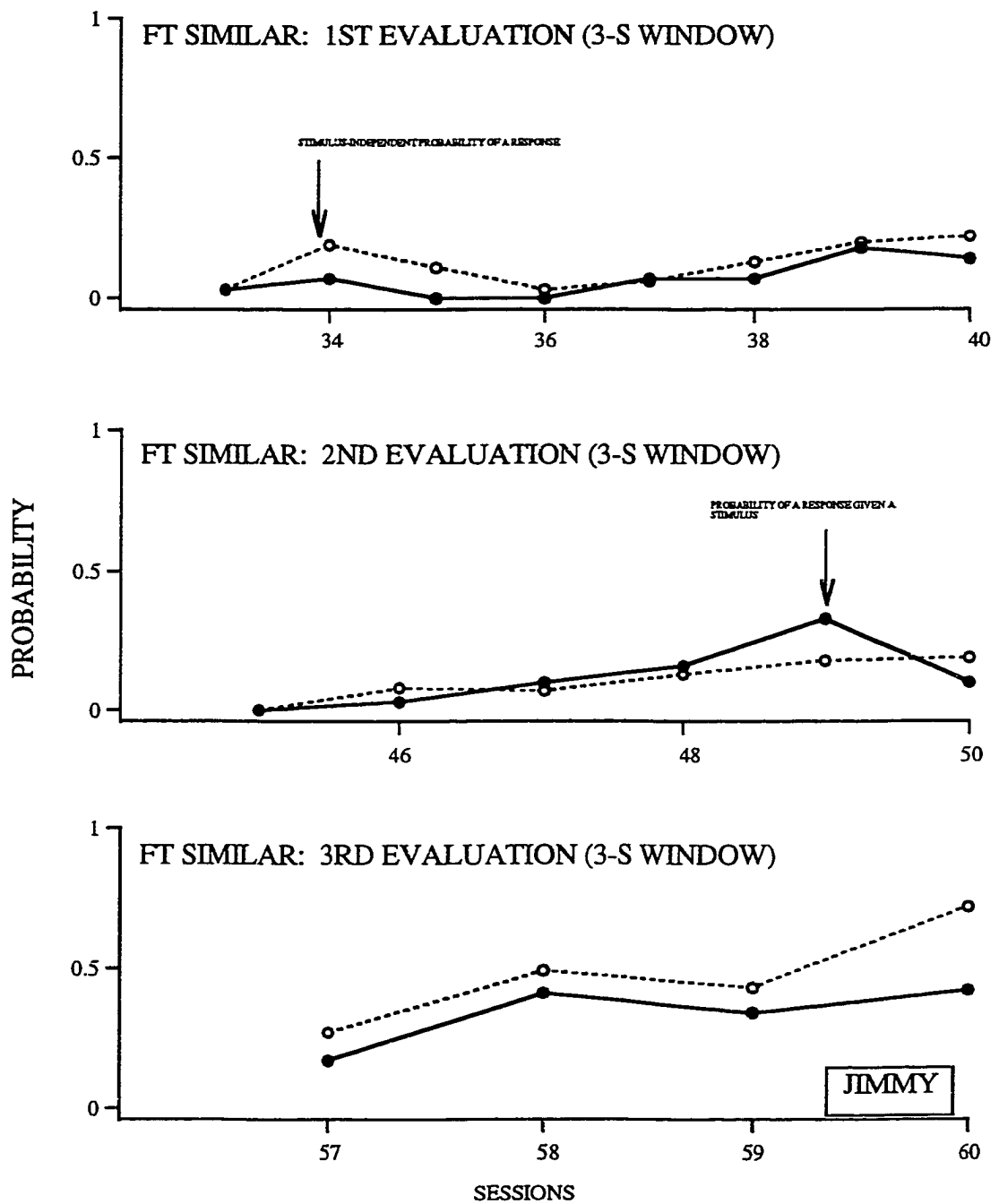


FIGURE 9. Stimulus-independent probability of response and probability of a response given a stimulus (within 3 seconds) during FT similar.

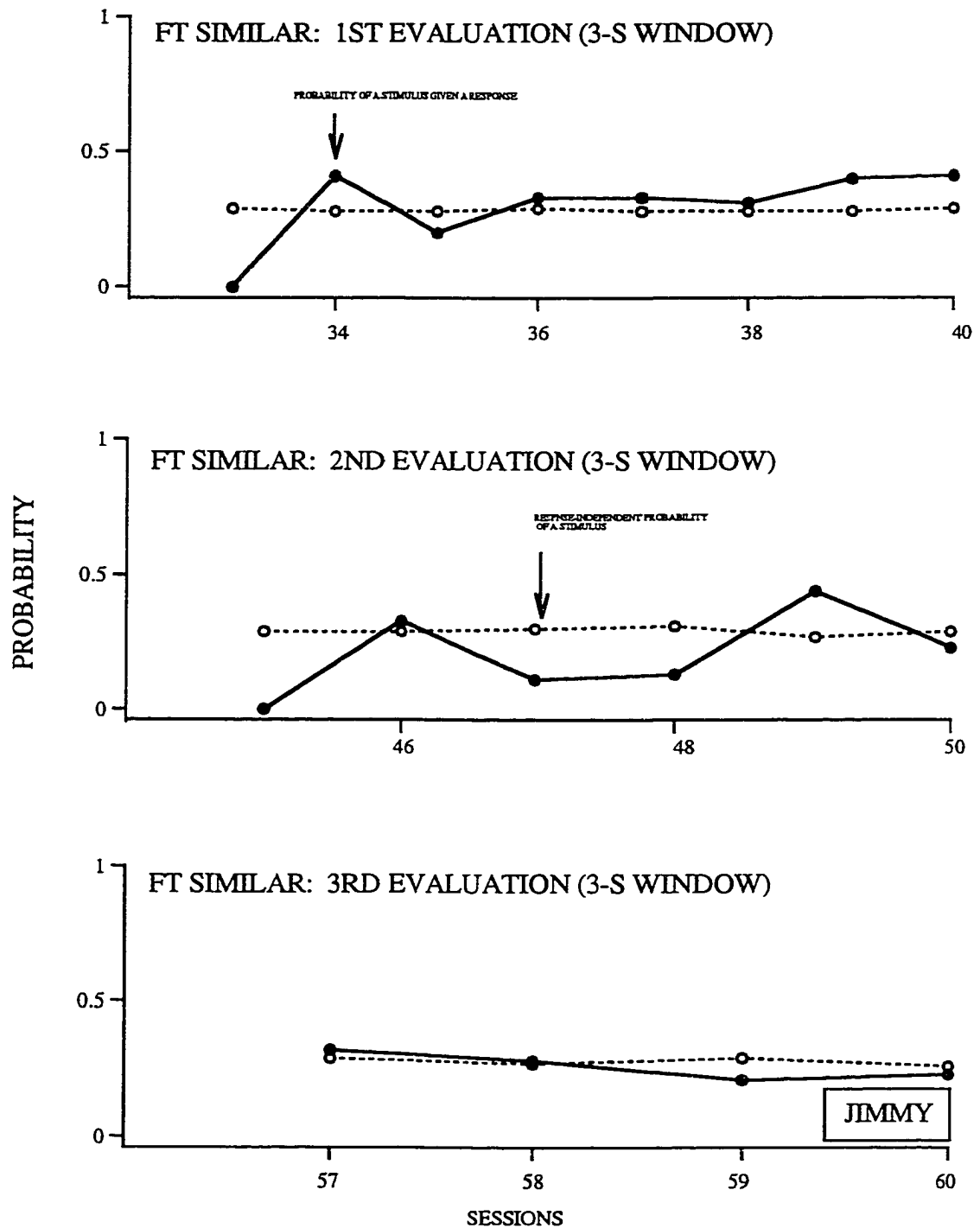


FIGURE 10. Response-independent probability of a stimulus and probability of a stimulus given a response (within 3 seconds) during FT similar.

sessions was .29 while the average for P2 (probability of a stimulus given a response; closed circles) across all FT-similar sessions was .26. Thus, no response-stimulus contingency was apparent.

Though no contingency was apparent in either analysis, Jimmy's responding maintained (in fact, increased) during FT-similar schedules. A third explanation, then, must account for continued responding. One possibility is that an immediately prior reinforcement history increased the sensitivity to any incidental response-reinforcer pairings. The implementation of a FT schedule presumably weakens contingencies. However, if some incidental pairings continue to occur, behavior might maintain. Therefore, "contiguity strength" was calculated for each participant.

In any response-dependent schedule, the probability of a stimulus given a response (P1) will always be greater than the probability of a stimulus preceded by no response (P2). In fact, the probability of a stimulus preceded by no response will always be zero. For example, even on a very lean response-dependent schedule (say, VR 1000), the probability of a stimulus given no response is still zero and the probability of a stimulus given a response is greater than zero. Similarly, in a strictly response-dependent schedule, the probability of a stimulus preceded by a response (P3) will always be greater than the probability of a stimulus preceded by no response (in fact, the probability of a stimulus preceded by a response will always be 1.0 while the probability of a stimulus preceded by no response will be 0). If these various relationships are plotted linearly, the greater the elevation of the data paths representing P1 and P3 relative to P2, the stronger the contiguity should be.

Figures 11, 12, and 13 display the results of the first type of contiguity strength analysis for Jimmy. These figure compare the probability of a stimulus given a response (P1; represented by the closed circles) and the probability of a stimulus preceded by no response (P2; represented by the open circles). Figure 11 displays the analysis conducted at the 3-second analysis level. The 6 and 9-second analysis levels are displayed by Figures 12 and 13 respectively. Through visual inspection, there does not appear to be a consistent contingency in place (that is, P1 is not greater than the P2). However, there is a change in the difference between the two data paths across sessions.



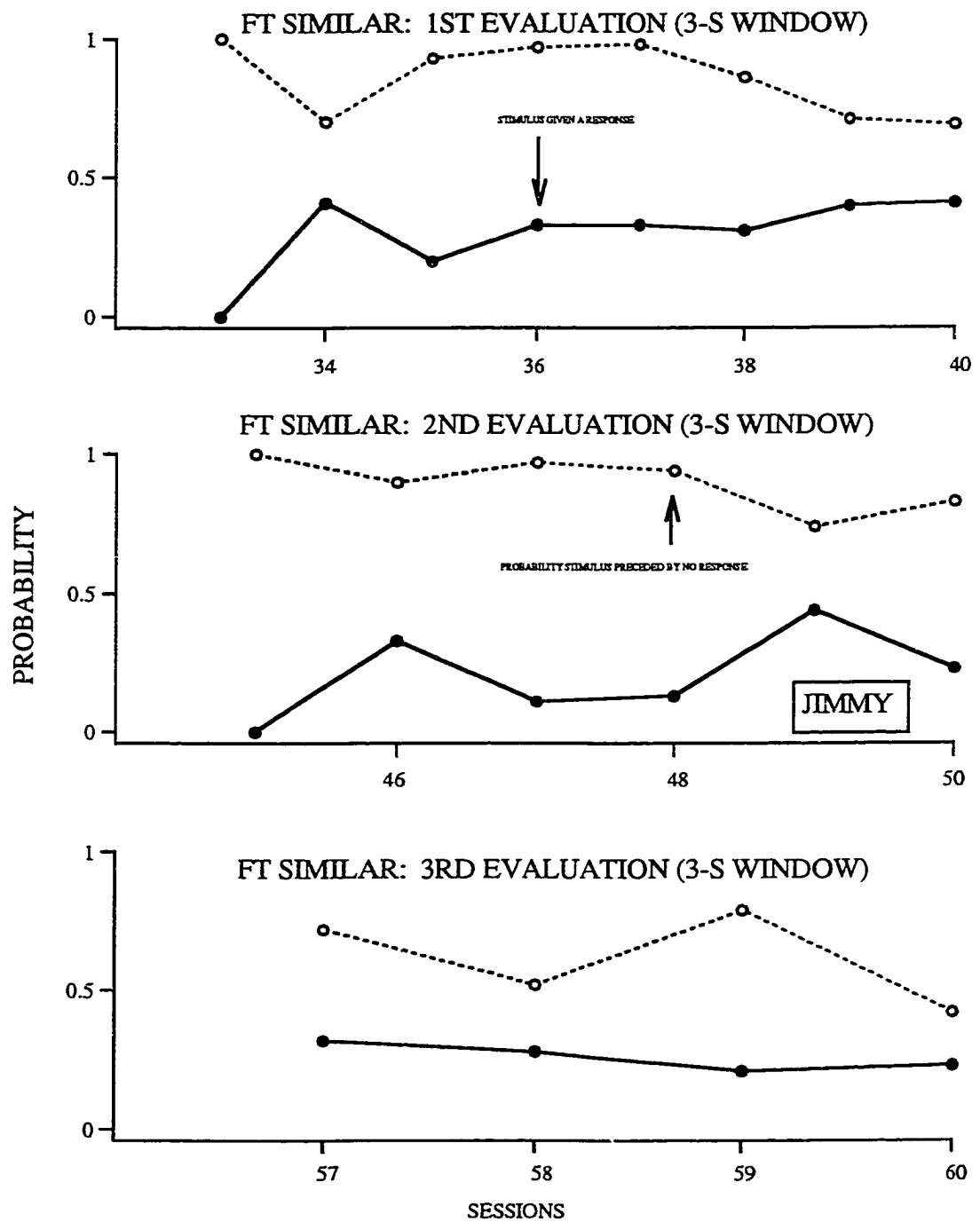


FIGURE 11: Probability of a stimulus given a response within 3 seconds and probability of a stimulus preceded by no response within 3 seconds.

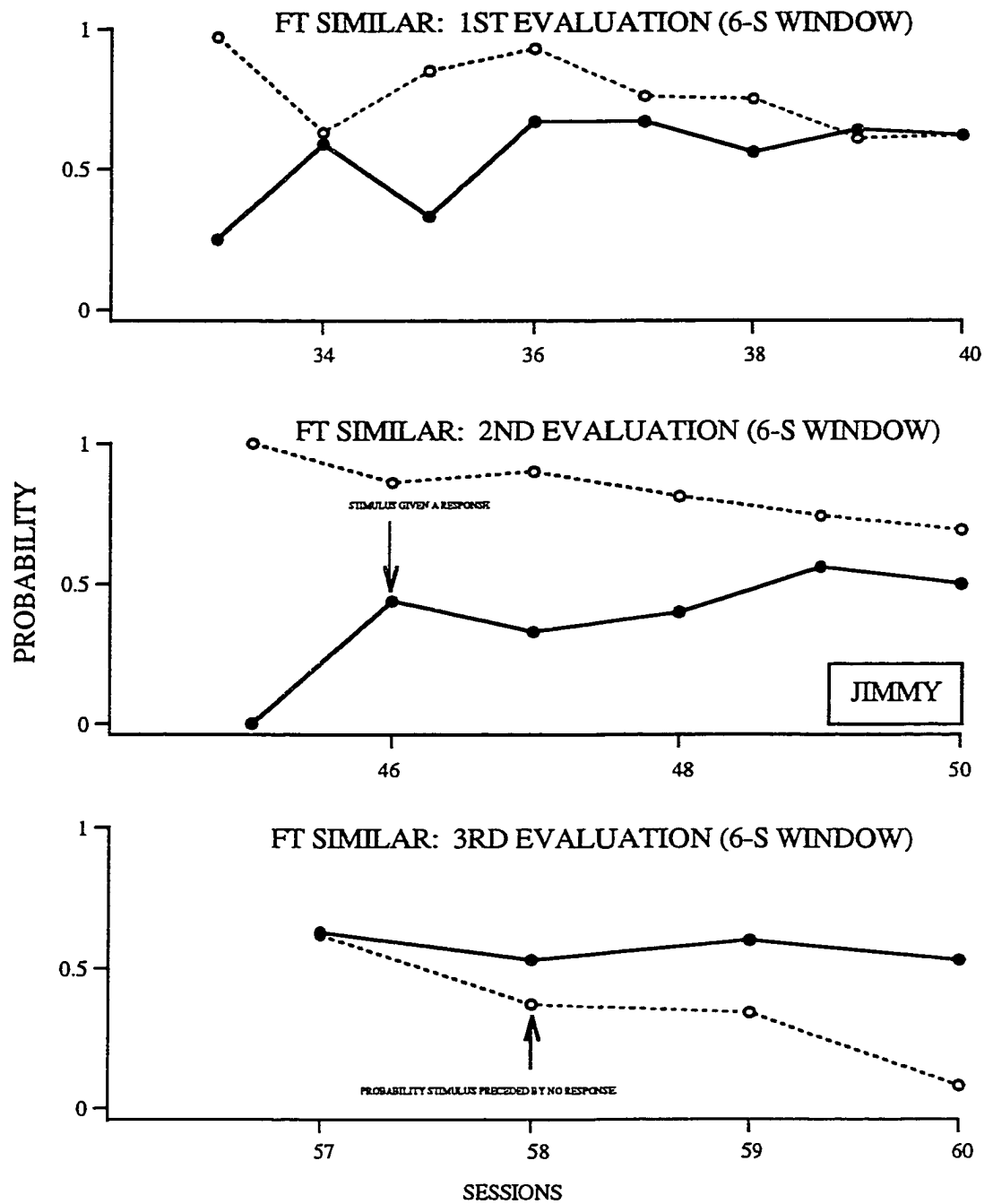


FIGURE 12: Probability of a stimulus given a response within 6 seconds and probability of a stimulus preceded by no response within 6 seconds.

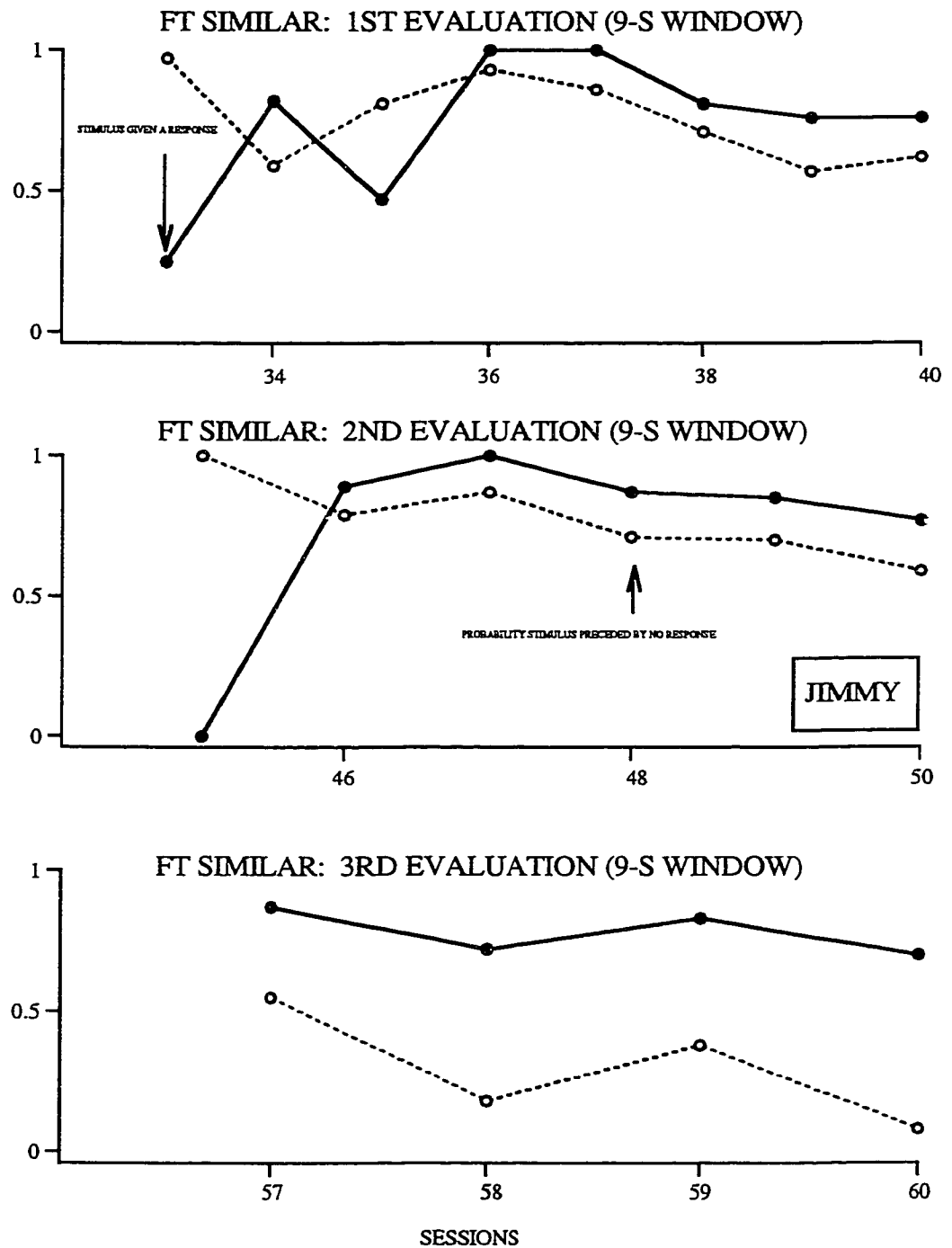


FIGURE 13: Probability of a stimulus given a response within 9 seconds and probability of a stimulus preceded by no response within 9 seconds.

In fact, at the 6 and 9-second analysis levels, there appears to be a contingency in place for the last four sessions. That is, the probability of a stimulus preceded by no response is eventually lower than the probability of a stimulus given a response.

Figures 14, 15, and 16 displays the results of the second type of analysis for Jimmy. This figure compares the probability of a stimulus being preceded by a response (P3; represented by the closed circles) and the probability of a stimulus being preceded by no response (P2; represented by the open circles). Figure 14 displays the analysis conducted at the 3-second analysis level. The 6 and 9-second analysis levels are displayed by figures 15 and 16, respectively. Through visual inspection, there does not appear to be a consistent contingency (that is, P3 is not greater than P2). However, similar to the previous contiguity analysis, the difference between the two data paths changes across sessions. Again, at the 6 and 9-second analysis levels, it appears more likely that a stimulus was preceded by a response than by no response during the last four sessions.

There are several limitations to the current study. First, the target behaviors chosen for investigation were of an arbitrary nature. Therefore, it is unclear as to how well the relationships present in this study would hold for clinically relevant behavior such as SIB, aggression, etc. Second, when response-dependent schedules were used, they were fixed schedules (either ratio or interval). In the natural environment, it is more likely that behavior is maintained on a variable schedules (either ratio or interval). It is possible that different results would have been reached had the response-dependent schedules been variable.

#### Future directions

At least three areas of research extend from the current study, each with potential relevance to application: 1) reinforcement parameters , 2) schedule parameters, and 3) mechanisms affecting behavior reduction.

#### **Reinforcement parameters**

In the current study, the reinforcement history for the target response was relatively short. It may be possible that longer reinforcement histories result in behaviors that are more resistant to change. The role of reinforcement history could be investigated

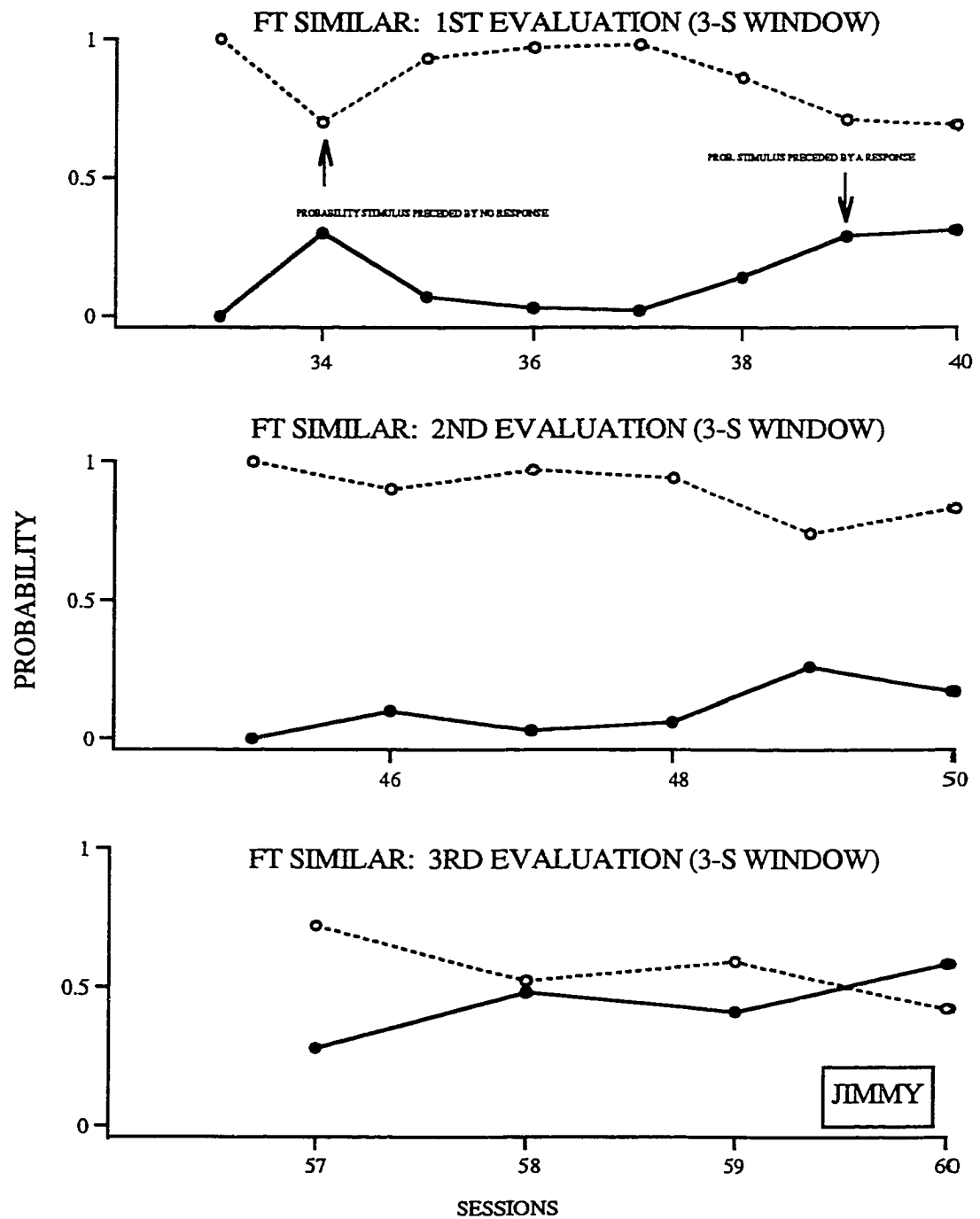


FIGURE 14. Probability of a stimulus preceded by no response within 3 seconds and the probability of a stimulus preceded by a response within 3 seconds during FT similar.

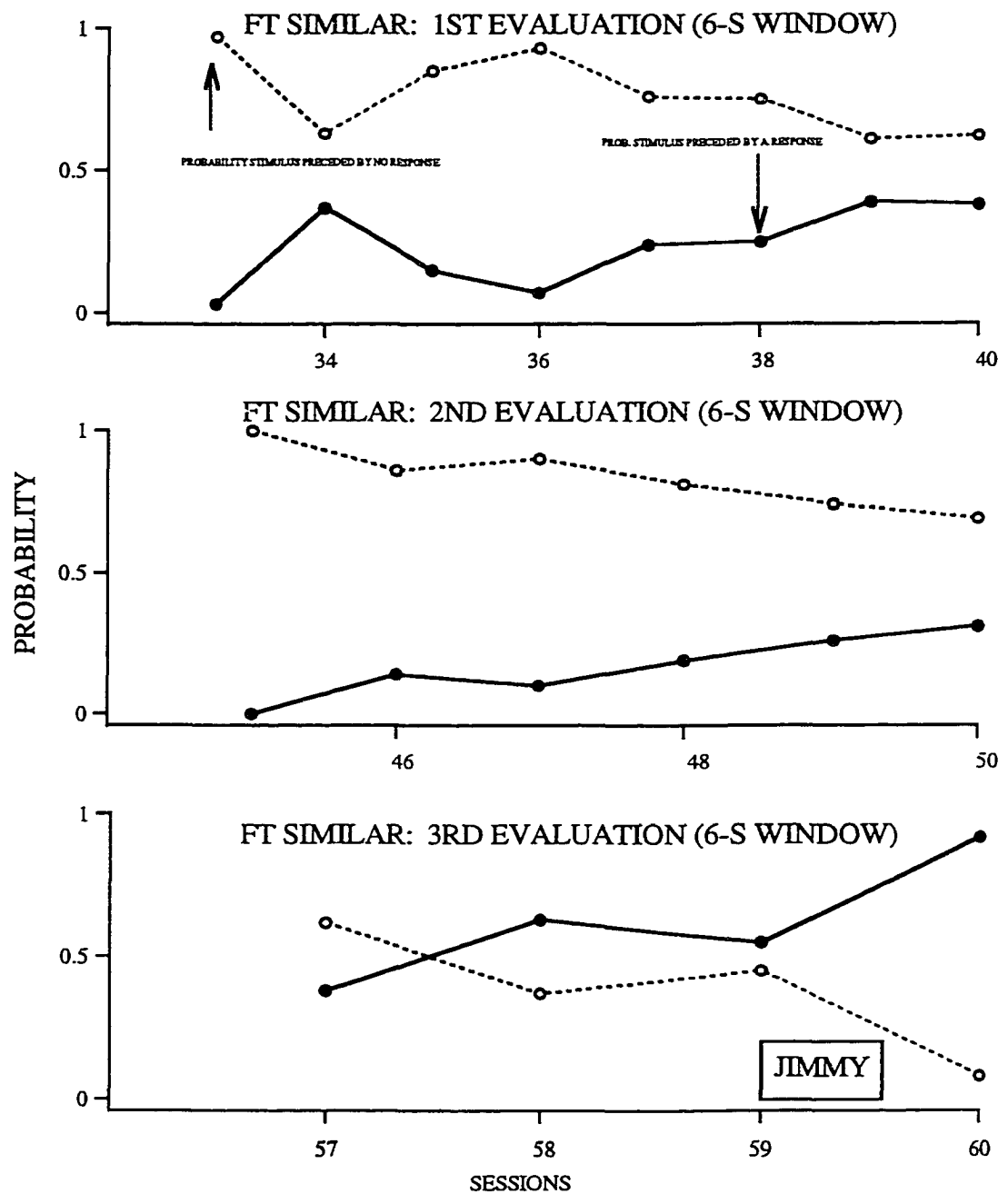


FIGURE 15. Probability of a stimulus preceded by no response within 6 seconds and the probability of a stimulus preceded by a response within 6 seconds during FT similar.

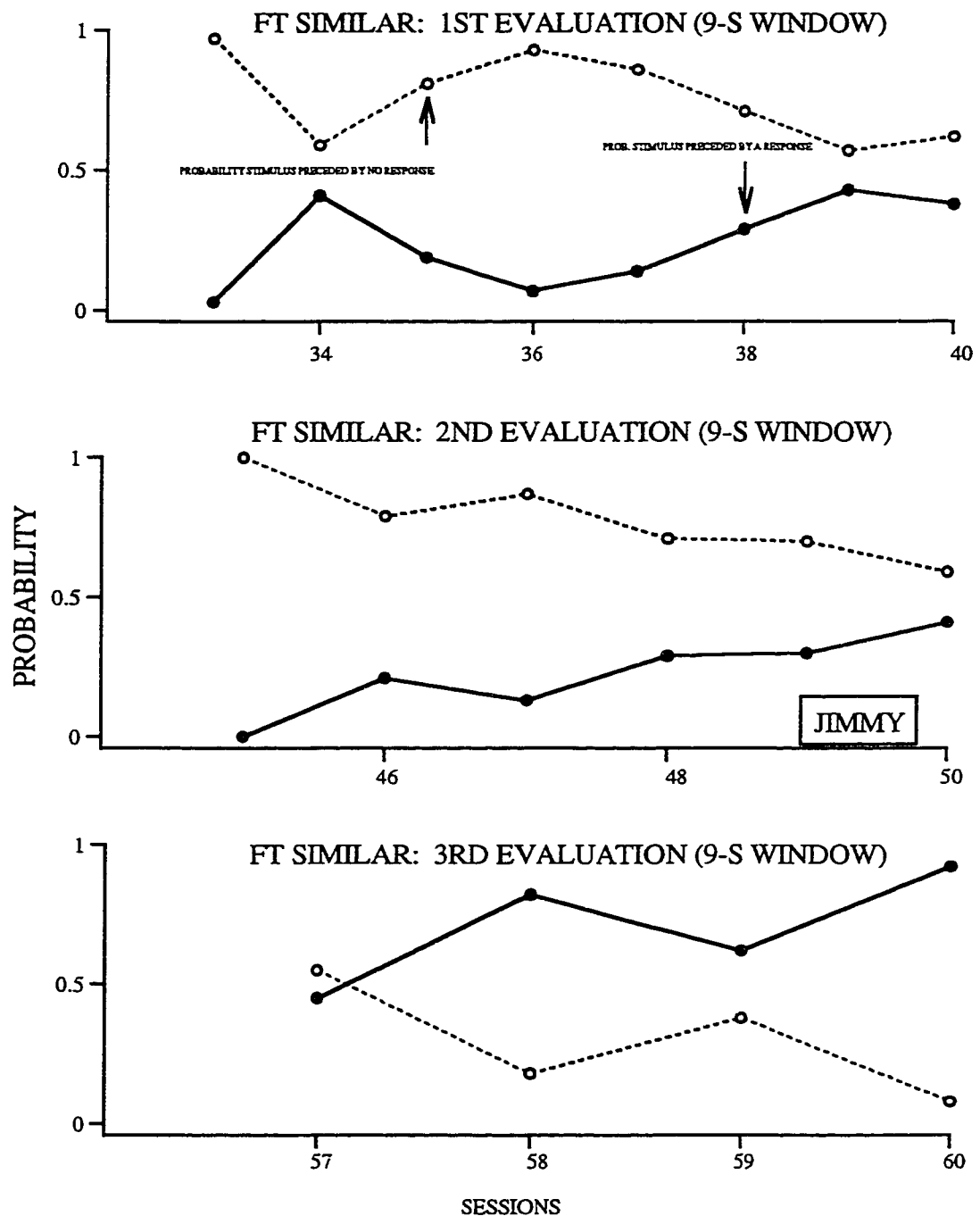


FIGURE 16. Probability of a stimulus preceded by no response within 9 seconds and the probability of a stimulus preceded by a response within 9 seconds during FT similar.

by systematically manipulating participants' exposure to response-dependent baselines. For example, in one component of a multiple schedule, behavior could be reinforced for a relatively long time (e.g., 100 sessions) while, in a second component, behavior could be reinforced for a relatively short period of time (e.g., 10 sessions), thus creating two distinct reinforcement histories. Following the predetermined number of response-dependent sessions, identical fixed-time schedules (in terms of discrepancy from baseline reinforcer rate) could be implemented in each component of a multiple schedule. The resistance to change during the various FT schedules could then be compared. If resistance to change differs across FT components, that difference could be attributed to reinforcement history.

Understanding the effects of various reinforcement histories may aid in clinical decision making. If longer reinforcement histories are correlated with more resistance to change during FT, schedules resulting in immediate behavior suppression (i.e., continuous reinforcement) might be indicated when the behavior has a long reinforcement history.

Recent investigations have demonstrated that arbitrary reinforcers (i.e., known reinforcers not responsible for a particular behavior's maintenance) delivered on response-independent schedules can reduce behavior (Fischer, Iwata, & Mazaleski, 1997). However, it is not clear how robust these effects are. Using functional reinforcers (i.e., reinforcers demonstrated to maintain a behavior), reductions in behavior have been achieved across relatively rich (Vollmer et al., 1993) and relatively lean schedules. The response reduction using arbitrary reinforcers reported by Fischer et al. was achieved with a relatively rich (i.e., continuous) reinforcer schedule. Using a relatively leaner schedule of response-independent stimulus delivery may not have the same effect if the reinforcer is arbitrary.

In order to assess the robust nature of noncontingent arbitrary reinforcer delivery, arbitrary reinforcers would have to be identified (using the methodology outlined by Fischer et al., 1997). Following a response-dependent baseline (during which functional reinforcers are delivered), the effect of various schedules of arbitrary reinforcer presentation could be evaluated by presenting arbitrary reinforcers according to various



FT schedules. Of particular interest would be the effect of lean FT schedules (as defined in the current study). If arbitrary stimuli are effective across reinforcer rate (i.e., result in response decrements), the practicality of using response-independent reinforcer delivery as treatment may be enhanced.

Several other reinforcement parameters could be investigated using a multiple-schedule preparation. For example, the effect of reinforcer magnitude could be evaluated by first maintaining behavior on identical response-dependent baselines. Following stable responding across baselines, identical FT schedules (based on discrepancy to baseline reinforcer rate) delivering reinforcers of different magnitudes could be implemented across components. Any difference in responding during these schedules could be attributed to magnitude differences. Similarly, for behaviors maintained by reinforcers that may involve a time dimension (e.g., escape from instruction, access to play materials), duration of reinforcement could be evaluated. During FT schedule evaluation, the independent variable would be the length of time the reinforcer was available. For example, a FT 1-minute schedule delivering 10 seconds of escape versus FT 1-minute schedule delivering 30 seconds of escape could be compared.

Information from these types of studies would have clinical relevance. For example, if high-magnitude FT schedules are demonstrated as more effective than relatively low-magnitude FT schedules, clinicians may want to prescribe high-magnitude schedules when treating behavior of a severe nature. As well, if duration of reinforcement availability is demonstrated to be a critical component of FT success, clinicians would need to ensure that adequate exposure to the reinforcer was programmed into the reinforcer schedule.

### **Schedule parameters**

In the current investigation, all reinforcer schedules (response independent and dependent) were fixed (i.e., FI or FT). Future studies could analogously evaluate the effect of variable ratio (VR) or VI schedules during baseline and ensuing VT schedules. For example, identical response-dependent baselines (VI, VR, FI, or FR) could be implemented on a multiple schedule. Following stable baselines, FT and VT schedules (controlling for reinforcer rate) could be compared in order to identify if, in terms of

behavior reduction, one is more efficient than the other. As well, VT schedules could be compared to extinction using a similar multiple-schedule preparation.

While FT schedules have been demonstrated to be effective in reducing behavior in clinical settings (e.g., Vollmer et al., 1993), there have not been any applied investigations evaluating VT schedules. Laboratory results (e.g., Zeiler, 1968) have indicated that VT schedules are more effective than FT schedules in reducing behavior. In addition, some applied studies have demonstrated that variable DRO intervals are more effective in reducing behavior than fixed DRO intervals. Thus, it may be that VT schedules are more effective than FT schedules and may be more pragmatic.

In addition to varying schedule type (fixed versus variable), other response-independent schedule parameters need to be studied. In the current investigation, response-independent schedules were either 6 times richer or leaner than a previous response-dependent baseline. This discrepancy was enough to achieve reduced response rates. However, it is unclear if the same results could have been obtained with slightly less discrepant schedules. Future studies could vary the degree to which schedules vary from reinforcer rate during baseline. For example, following response-dependent baselines, FT schedules four times as dense or as lean could be evaluated. Results of these studies may identify how discrepant FT schedules must be in order to achieve behavior reduction. If an optimal discrepancy (i.e., those that balance reinforcer amount and behavior reduction) can be identified, clinicians could maximize efficiency when prescribing response-independent schedules as treatment.

### **Mechanisms**

The mechanism(s) underlying FT effects remains unclear. Some studies have implicated satiation (Lalli et al., 1997) while others have implicated extinction (Marcus & Vollmer, 1996). It would be important, from a conceptual standpoint, to continue conducting investigations designed to clarify the roles of satiation and extinction. Because FT-dissimilar schedules, regardless of reinforcer rate, resulted in behavior reduction, results of the current study suggest that extinction may be the mechanism responsible for behavior reduction. If satiation were the sole mechanism responsible for behavior reduction, reduction would only have been evident during the relatively rich

schedules. However, other factors such as a history with extinction and other FT schedules may have contributed to behavior reduction during FT-dissimilar schedules that were relatively lean. More controlled evaluations, designed specifically to address the roles of extinction and satiation should be conducted. One possible way to examine extinction and satiation would be to evaluate the schedule effects of different FT densities. For example, following response-dependent baselines (presented on a multiple schedule), two separate FT schedules (relatively lean and relatively rich) could be implemented. In both cases, extinction would be in place (that is, responding would not result in reinforcer delivery) while reinforcer rate would vary. If behavior decreased only in the FT-rich schedule, satiation would be implicated. If behavior decreased in both conditions, extinction would be implicated.

It may be possible that satiation and extinction are responsible for behavior reduction. However, depending on the schedules, one may be a critical component. Behavior has been demonstrated to decrease when reinforcers are delivered on a frequent basis independent of a extinction component (Lalli et al., 1997), implicating satiation as the controlling factor. However, the data from the current study indicate behavior reductions occur when reinforcers are presented on an infrequent basis, implicating extinction as the critical element. It may be that either will result in behavior change, depending on the reinforcer rate.

Understanding the relative contributions extinction and satiation make regarding response reduction during response-independent schedules may impact clinical application. For example, in some instances, it may be impractical or impossible to withhold the maintaining variable following problem behavior (i.e., extinction cannot be implemented). When this is the case, it would be important to know what type of response-independent schedule would be effective in the absence of an extinction component.

Given the results of the current studies, and the apparently idiosyncratic results of previous studies, other mechanisms may be responsible for behavior reduction during FT schedules. It may be that FT schedules, when distinct from baseline schedules, constitute a challenge to response strength. Response strength can be defined as the

resistance of a behavior to change (Catania 1992). During a FR 1 reinforcer schedule, no challenges are made to the response-reinforcer relationship, resulting in low response strength. When distinct FT schedules are implemented, the result is a challenge to response strength (either by responses not being reinforced, or by reinforcers being delivered in the absence of responding). The result is a change in behavior (i.e., decreased responding). Fixed-time schedules that are not distinct from baseline reinforcer rate (e.g., FT similar) pose less of a challenge to response strength. Thus, behavior during these schedules does not change to the same degree as during FT-distinct schedules.

The contribution that response strength makes to behavior change during FT schedules could be empirically evaluated. Using a multiple schedule design, two response-dependent schedules could be implemented. In one component, a FR-1 schedule would be in place. In a second component, a VI schedule yoked to the FR-1 sessions would be implemented (e.g., if 2 reinforcers per minute were delivered during a FR-1 session, the schedule for the next VI session would be VI 30 seconds). This procedure would ensure equal reinforcer rates across schedules. However, behavior in the VI schedule would be of a greater response strength due to a high likelihood of non-reinforced responses. When stable responding is observed in each component, distinct FT schedules could be implemented in each component of a multiple schedule. If response strength affects behavior during FT schedules, behavior during the distinct FT schedules following the FR 1 baseline should be less resistant to change than behavior during the FT schedules following the VI baseline. If this relationship between response strength and FT schedules is observed, it may be important, from an applied perspective, to weaken response strength prior to implementing FT-based treatments.

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## VITA

Joel E. Ringdahl is a doctoral candidate in school psychology. He received his bachelor's degree from the University of Florida in May, 1992 and his master of arts degree from Louisiana State University in December, 1995. Joel's areas of interest include applied behavior analysis, developmental disabilities, and severe behavior disorders. He is currently the director of the Biobehavioral Service at University Hospital School, The University of Iowa. His future plans include conducting research and clinical practice designed to investigate factors affecting human behavior, specifically in the area of severe behavior disorders. He will receive the degree of Doctor of Philosophy in May, 1999.



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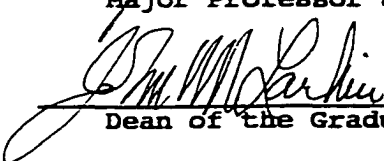
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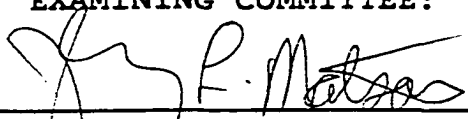
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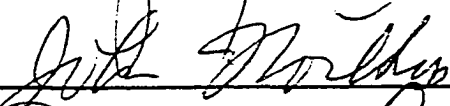
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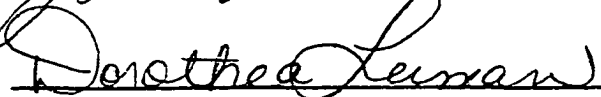
  
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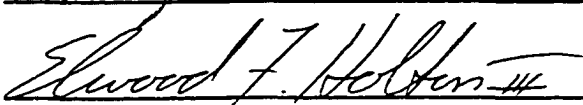
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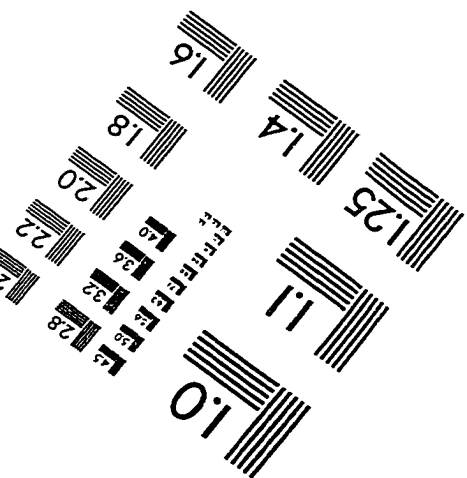
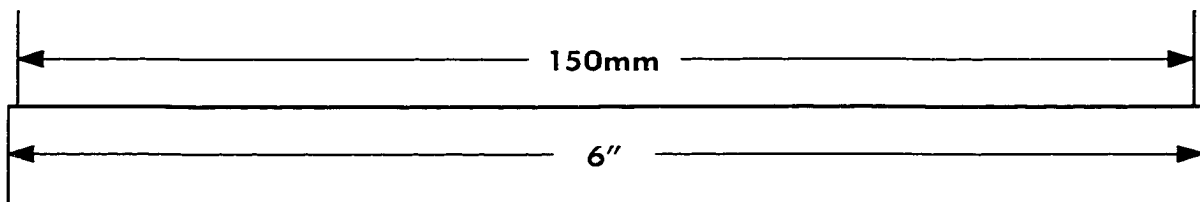
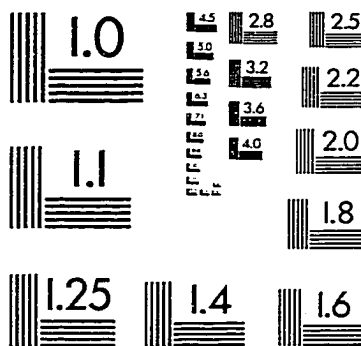
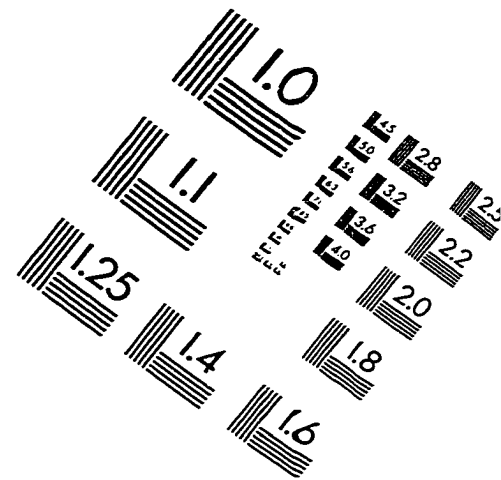
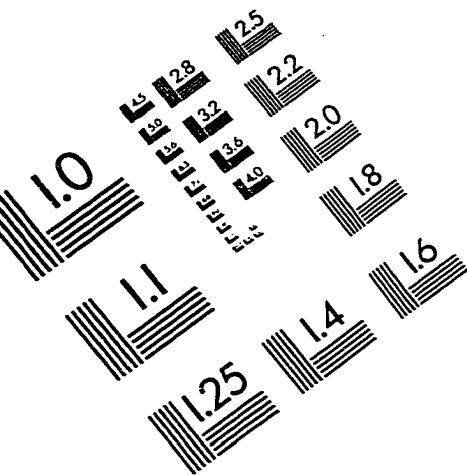
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